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Designing an (s, S) Inventory Control System

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18 July 1997

Abstract

This project aims to provide some insight on a local company's (s, S) inventory control system. It does so by providing three completely new (s, S) approaches and comparing their simulated performance to the current system. Recommendations are made based on the results.

1 Introduction: Quantegy, Inc.

Quantegy, Inc. (formerly known as Ampex) is an Opelika company that manufactures magnetic tape for worldwide distribution. It has been the sole producer of magnetic tape in the United States since last year, when Quantegy's only competitor, 3M, left the market. The company has been in business for over 50 years. Annual sales presently average $120 million. Management estimates that nearly $15 million is currently invested in worldwide inventory.

The facility in Opelika is Quantegy's only manufacturing plant. It also serves as the company's headquarters. Quantegy maintains ten regional distribution centers in North America, six in Europe, one in Asia, and one in Australia. These regional facilities conduct Quantegy's business in their respective areas, having their inventories periodically replenished with shipments from Opelika.

Quantegy uses an (s, S) inventory control policy to keep its regional facilities stocked. Specifically the inventory at each facility is reviewed from one to three times per week. When the inventory level for a particular stock keeping unit (hereafter an SKU) is found to be below its reorder point s, then a replenishment order is placed to Opelika. The amount

of the order is equal to the difference between the current inventory level and that SKU's order-up-to level S. All order amounts are integer multiples of the standard package size for that particular SKU. The distribution center can expect to receive the order after a delivery lagtime.

The reorder point s and order-up-to level S change from week to week, based on the demand forecast for that particular SKU. The forecast for the next week's demand is simply the average demand over the last 13 weeks (i.e. a 13 week moving average). The order-up-to level S is this forecast multiplied by a number called the ABC factor and then rounded to the nearest standard package size. Quantegy classifies its SKU's according to their own ABC system, where A items are the most important. Their system does not, however, use the classic Pareto rule (80/20) [1]. Instead each sales region requests a specific classification that is subject to the main planning department's final decision. The ABC factor is just a number that management creates and can adjust in times of irregular demand. The factor is typically larger for A items (e.g. 3) than for B or C items (e.g. 2.5). The reorder point s is 90% of the order-up-to level S, again rounded to the nearest standard package size.

For example, assume a B item. Its ABC factor is, arbitrarily, 2.5. Assume the average demand for the product over the last 13 weeks is 26.78 SKU's. The standard package size for this product is 10. It follows then that the order-up-to level S is $26.78 * 2.5 = 66.95 \approx 70$. The reorder point s is $90\% * 66.95 = 60.255 \approx 60$.

Each region also provides Opelika with its own demand forecasts to take into consideration when evaluating its inventory. The general idea is that the regional personnel should know when something irregular is happening in their area of responsibility. But these forecasts, however, are notoriously large. Regional managers evidently provide inflated numbers to maximize their own inventories at the expense of the other regions. As a result, the regional forecasts are virtually ignored by Opelika except in the most extreme cases.

Quantegy measures its fillrates by calculating the percentage of orders that are fulfilled

by on-hand demand. The sizes of the orders and the stockouts are ignored. Management typically expects A items to achieve a 95% fillrate and B items to achieve a 90% fillrate. C and D items are not expected to achieve anything close to 90%.

2 Project Overview

The project objective is to evaluate Quantegy's current (s, S) inventory control system (section 6) against the three different (s, S) approaches presented in this paper (sections 7-9). Evaluation comes in the form of a deterministic simulation (section 5) that uses actual demand data provided by analysts in Opelika (section 4). The results are then compared to the present system's simulated performance and recommendations are made (section 10).

The methodology used is relatively straightforward. The data is first partitioned into two sets. The first set, called the sample, is used to initialize the approach being looked at. (A "policy" or "approach" is simply how the s and S values are being computed.) No modifications to the control policy are allowed after initialization. The policy is then evaluated via simulation on the second set of demands, called the ex post [2]. Assuming a valid simulation, this approach discovers what would have happened (i.e. fillrates, number of orders, average on-hand inventory) had Quantegy actually implemented the policy in question, during the times represented by the ex post set, without any knowledge of the future (ex post) demands.

This analysis will hopefully provide management at Quantegy with a different perspective and some fresh insight on their inventory control system. This project does not claim to offer a panacea for all of Quantegy's inventory problems. Instead it offers some practical alternatives that appear to have significant and realistic improvements on paper.

3 Literature Review

The main research paper behind this project is [14]. It is an efficient approach that uses renewal analysis to find the minimum cost (s, S) policy (long-run expected holding, setup, and penalty). The authors themselves improve upon the work of [12], who solve the same problem by inefficiently enumerating all solutions in the (s, Δ) plane and selecting the policy with the minimum cost.

Another paper worth mentioning is [7], which details a non-exact heuristic to solve the (s, S) problem subject to a Type 1 fillrate constraint (fraction of non-stockout time periods). This project attempts to do the same, but with renewal analysis and a Type 2 fillrate constraint (fraction of non-stockout orders). A classic paper on the (s, S) problem that was looked at but not used is [9], where the author introduces three methods for computing approximately optimal (s, S) policies for discrete time shortage cost systems.

[13] provides Croston's method, an advanced forecasting technique used in the project. [4] enables the avoidance of the common mistake of underestimating fillrates. Numerous textbooks provide miscellaneous support.

4 Data

Quantegy was able to provide data on 14 A items and 11 B items in their New York distribution center. Specifically they provided each item's standard cost, and the quantity shipped of that item to New York from Opelika every week, from June 1993 to October 1996 (172 weeks total). Needless to say, this data is not the actual *demand* for those items. It is, however, a reasonably close substitute and the only information Quantegy could give.

The raw data (attachment 1) can be generally described as erratic. Each item displays its own behavior such as trends, bulges, cutoffs, and long periods of inactivity. Graphs of the raw weekly demand for items A14 and B04 are included in attachment 2 as arbitrary

examples. The most notable characteristic common to all is the existence of outliers. Each item had at least one week in which the recorded demand was more than three standard deviations from the mean demand [6]. Such behavior is sure to pollute even the most robust control policy's performance. It is reasonable to assume that management knows about such aberrant orders beforehand and can prepare accordingly. To reflect this assumption and avoid the degradation of simulated performance, each data point that lies more than three standard deviations from the mean is replaced with the original sample mean. A summary of the exact changes is included in attachment 3. This outlier adjusted data (attachment 4) is much more tractible and predictably has lower means and standard deviations.

The next major modification dealt with changing the frequency of observations from every week to twice per week. Such a change is necessary because the inventory levels are reviewed twice per week at the New York facility. Converting the weekly numbers involves randomly splitting each observation into two half-week observations. But some extra analysis (below) is needed to avoid the high probablilty of these half-week observations always coming in pairs, an outcome that was pointed out at a presentation of this project at a local APICS meeting in February 1997.

Let f be the probability of demand in a particular week. Estimate it by dividing the number of non-zero observations by the total number of observations (172). Let p be the probability of demand in a particular half-week and assume that half-week demand is independent and identically distributed. The probability then of not incurring a demand in any week $(1-f)$ should be equal to the probability of not incurring a demand in both the first half and second half of any week $((1-p)*(1-p))$. Solving for p results in the following equation.

$$p = 1 - \sqrt{1-f} \qquad (1)$$

[The above equation can be generalized for any number n of time periods within the week

with the expression $p = 1 - \sqrt[n]{1-f}$.]

There are two possible outcomes regarding the half-week demands, given that a non-zero demand has occurred. Either (1) the demand is split between both half-weeks or (2) the entire amount occurred in either the first or second half of the week. The probabilities of each of these occurrences can be calculated using conditional probabilities and the value of p above.

- P(Demand in both halves | Non-zero weekly demand)=$\frac{p^2}{p^2+2p(1-p)} = \frac{p}{2-p}$
- P(Demand in only one half | Non-zero weekly demand)=$\frac{2p(1-p)}{p^2+2p(1-p)} = \frac{2-2p}{2-p}$

The conversion procedure logically follows, where D is the observed weekly demand, D_1 is the resulting demand in the first half of the week while D_2 is the resulting demand in the second half of the week.

Week to Half-week Conversion Procedure

For every item

- Calculate p
- For every week
  - If $D > 0$ then
    * Generate x =U(0,1)
    * If $x \leq \frac{p}{2-p}$ then **demand in both halves**
      · Generate y =U(0,1)
      · $D_1 = y * D$ rounded to the nearest standard package size
      · $D_2 = D - D_1$
    * Else if $x \leq \frac{1}{2-p}$ then **demand in first half only**
      · $D_1 = D$
      · $D_2 = 0$
    * Else **demand in second half only**
      · $D_1 = 0$
      · $D_2 = D$
  - Else **no demand in either half**

* $D_1 = D_2 = 0$

The set of half-week data used throughout this project that results from the above stochastic procedure is included in attachment 5.

The final modification, as described above, is to partition the data into the sample and ex post sets. The last year of data (51 weeks as defined by Quantegy) seemed an intuitively attractive amount of time for the ex post set, which provides ample data for initialization within the sample (121 weeks). This partition is represented by the horizontal line in attachment 5.

5 Simulation

As already stated, the simulation used to evaluate the inventory control policies is deterministic. It simply uses the half-week demands obtained above as the actual demands in the simulation, in the same order and with no changes.

Define the following. . .

$t \rightarrow$ the time period in half-weeks
(e.g. half-weeks 30.5 and 31.0 are the first and second halves of week 31, respectively)
$Y_t \rightarrow$ the demand in t
$s_t \rightarrow$ the reorder point in t
$S_t \rightarrow$ the order-up-to level in t
$I_t \rightarrow$ the inventory position at the end of t
$N_t \rightarrow$ the net inventory at the end of t
$Q_t \rightarrow$ the amount of the order placed in t
$q_t \rightarrow$ whether or not an order was placed in t (1 is yes, 0 is no)
$H_t \rightarrow$ the on-hand inventory at the end of t
$B_t \rightarrow$ the amount of the backorder in t

The simulation then is just the act of making the following calculations for every t. . .

$I_t = I_{t-0.5} - Y_t + Q_{t-0.5}$
$N_t = N_{t-0.5} - Y_t + Q_{t-1.0}$
$Q_t = S_t - I_t$ if $I_t \leq s_t$, otherwise $Q_t = 0$
$q_t = 1$ if $Q_t > 0$, otherwise $q_t = 0$
$H_t = N_t$ if $N_t > 0$, otherwise $H_t = 0$

$B_t = -N_t - max(0, B_{t-0.5} - Q_{t-1.0})$ if $N_t < 0$, otherwise $B_t = 0$

To initialize, $Y_0 = 0$, $I_0 = N_0 = S_{0.5}$, and $N_{0.5} = N_0 - Y_{0.5}$.

Some things are worth mentioning here. Quantegy updates the s and S parameters every week. As a result, $s_t = s_{t+0.5}$ whenever $t + 0.5$ is an integer. The same holds true for S. The equation for inventory position adds in the order from the last period because the delivery lag to New York is half a week long. The equation for net inventory adds in the order from an entire week prior to keep the on-hand inventory as accurate as possible for holding cost estimates. The expression for backorders prevents previous stockouts from being double counted if a demand is larger than normal.

The first measure of performance is the number of orders made by a policy. The fewer orders a policy has to make, the better in terms of ordering costs. It is calculated simply by summing the q_t values. The next measure is the average on-hand inventory and is calculated by averaging the H_t values in the simulation. Again, this measure is desired to be as small as possible to cut holding costs. The final measure of performance is the fillrate, calculated by the expression below.

$$1 - \frac{\sum_t B_t}{\sum_t Y_t} \tag{2}$$

This is commonly referred to as the β, or Type 2, fillrate and is different from the fillrate that Quantegy uses, commonly called the α, or Type 1, fillrate [8]. The difference is that the β value measures the units of demand that were filled with on-hand inventory while the α value measures the number of *orders* (or time periods) that were filled *entirely* by on-hand inventory, regardless of the size of the stockout. The β value is used because it gives better information. Take the case where 99 of 100 orders were filled by on-hand inventory. The α fillrate here is equal to 99% because 99 of the 100 orders were filled. But now assume that there were 10000 total units demanded during all of these orders and that the one missed order (entirely!) was for 9901 units. The corresponding β value here is 1%, a much more

indicative number for the situation. Unlike the other measures of performance, the fillrate is desired to be as close to 1 as possible (maximized) and no smaller than the service objectives set by management.

6 Quantegy's Current Policy

Recall that Quantegy uses a dynamic inventory control policy where the values of s and S are updated every week.

Define the following. . .

$\hat{Y}_t \rightarrow$ the demand forecast for t
$S_t^o \rightarrow$ the order-up-to level in t before rounding
$s_t^o \rightarrow$ the reorder point in t before rounding
$\kappa \rightarrow$ the ABC multiplier (3 for A items, 2.5 for B items)

Then for every integer value of $t + 0.5$. . .

$\hat{Y}_t + \hat{Y}_{t+0.5} = \frac{\sum_{last13weeks} Y_t}{13}$
$S_t^o = \kappa * (\hat{Y}_t + \hat{Y}_{t+0.5})$
$s_t^o = 0.9 * S_t^o$
$S_t = S_{t+0.5} = S_t^o$ rounded to the nearest standard package size
$s_t = s_{t+0.5} = s_t^o$ rounded to the nearest standard package size

This policy uses only the last 13 weeks of the sample set to initialize the moving average. The detailed results of the ex post simulations for all 25 items are included in attachment 6. The table below summarizes the simulated performance of Quantegy's current inventory control policy. Overall the policy made a total of 1200 orders for all 25 items (out of a possible 2550). It kept an estimated $98,408.33 worth of inventory on the shelves. Of the 25 items, 15 had fillrates of at least 90%. The average fillrate for the entire policy was 86.8%.

Since Quantegy does not keep information on past inventory performance, it is nearly impossible to exhaustively validate the simulation. Management did, however, indicate that the numbers were "reasonable" and "seemed right" in a meeting back in December of 1996.

Performance Measure	Current Policy
Total Orders	1200
Avg OH Inv ($)	98,408.33
# Fillrates $\geq$ 90%	15
Avg Fillrate	86.8%

Table 1: Performance of the Current Policy

7 Alternative 1: Different Forecasts

This approach tests the intuition that Quantegy's inventory control policy would perform better with a more accurate and sophisticated forecast than a 13-week moving average. It does so by replacing the moving average with three alternatives. No other changes are made to the policy.

The first forecasting alternative is the naive forecast, where the demand for the current week is simply the observation in the previous week. It uses only the last week of demand in the sample set to initialize. This forecast should perform poorly compared to the moving average and, as a result, have worse inventory performance. It is defined by the following equation, where $t + 0.5$ is again an integer.

$$\hat{Y}_t + \hat{Y}_{t+0.5} = Y_{t-1.0} + Y_{t-0.5} \tag{3}$$

The second alternative is to use the mean demand over the entire sample set as the forecast for every demand in the ex post set. Needless to say it needs the entire sample set to initialize. This forecast results in a static policy where the values for s and S are constant over the entire simulation. Like above, this forecast should perform poorly both in terms of accuracy and inventory performance compared to the moving average. This forecast is defined by the following equation, where $t + 0.5$ is integer.

So why say it!

$$\hat{Y}_t + \hat{Y}_{t+0.5} = \frac{\sum_{sample} Y_t}{121} \tag{4}$$

The final alternative is called Croston's method [13]. It is a variant of single exponential smoothing that was designed to forecast random and intermittant demand like the data in this project. Specifically it makes separate exponential smoothing estimates for both the average size of a demand and the average interval between demands. The forecast is the ratio of these two values, or the expected demand per interval. It is only updated when a demand occurs. If demand is occurring in every time period, then Croston's method is equivalent to single exponential smoothing. Unlike the other alternatives, this forecast should be more accurate than a moving average and, as a result, have superior inventory performance.

Define the following. . .

$Z_t \rightarrow$ the estimate for the size of demand in t
$P_t \rightarrow$ the estimate for the time interval between demands in t
$d \rightarrow$ an integer counter
$\alpha \rightarrow$ smoothing parameter between 0 and 1

Croston's method follows, where $t + 0.5$ is an integer.

- If $Y_t + Y_{t+0.5} = 0$ then
  - $Z_t + Z_{t+0.5} = Z_{t-1} + Z_{t-0.5}$
  - $P_t + P_{t+0.5} = P_{t-1} + P_{t-0.5}$
  - $d = d + 1$
- Else
  - $Z_t + Z_{t+0.5} = Z_{t-1} + Z_{t-0.5} + \alpha * (Y_t + Y_{t+0.5} - Z_{t-1} + Z_{t-0.5})$
  - $P_t + P_{t+0.5} = P_{t-1} + P_{t-0.5} + \alpha * (d - P_{t-1} + P_{t-0.5})$
  - $d = 1$
- $\hat{Y}_t + \hat{Y}_{t+0.5} = \frac{Z_{t-1}+Z_{t-0.5}}{P_{t-1}+P_{t-0.5}}$

confusing

Initialization here uses the entire sample set and is a bit more involved. $Z_{-0.5} + Z_0$, or the initial estimate for the size of the demand, is the average size of the non-zero demands from $Y_{0.5}$ to $Y_{10.0}$, the first ten weeks. $P_{-0.5} + P_0$, or the initial estimate for the time interval,

is the average size of the time intervals between $Y_{0.5}$ to $Y_{10.0}$, cutting off the last interval if undefined by time 10.0. The first d value is 1. The initial α value is 0.1. A search procedure (Excel solver) is then performed on α to find a local minimum for the mean squared error (hereafter MSE) of this forecast over the sample set. Recall that the MSE is simply the average squared difference between forecast and observation over all relevant time periods. The initialization results are included in attachment 7.

Using MSE as the only forecast accuracy measure, the initialized naive and mean forecasts are less accurate over the ex post sample, as expected. The naive forecast results in MSE's that are 93% more, on average, than the MSE's produced by the 13 week moving average. The mean forecast is not as bad, having MSE's that are only 38% greater. Croston's method, on the other hand, is slightly more accuarate than the moving average. It produces MSE's that are overall 1% lower. The specific accuracies for each item and each forecast are included in attachment 8.

The simulated performances of the three forecasts are summarized in the table below. The complete simulation results are included in attachment 9.

Performance Measure	Naive	Mean	Croston
Total Orders	590	1323	1151
Avg OH Inv ($)	173,144.69	41,052.26	98,448.15
# Fillrates $\geq$ 90%	22	6	18
Avg Fillrate	95.8%	70.2%	90.6%

Table 2: Performance Comparison For Different Forecasts

8 Alternative 2: A Two-Stage Heuristic

This approach relies heavily on the renewal analysis presented in [14] and is a complete change from Quantegy's current policy. The first stage involves selecting a $S - s$ value for

each item by matching its classic economic order quantity (EOQ) to the corresponding order quantity defined by the renewal equations. The second stage involves increasing each item's s from 0, and likewise S from $S - s$, until the desired fillrate is achieved in the renewal analysis. The simulated performance of these static s and S values is then evaluated for each item in the ex post simulation for comparison with the other methods.

Some initialization is required, however, before beginning the heuristic. The first thing to be done is to choose, for each item, a discrete probability distribution to represent its demand. This was accomplished by fitting the first two moments of the half-week demands in the sample set, divided by their standard package sizes, to the negative binomial distribution defined below. The choice of distribution is appropriate (as compared to choosing the traditional normal, poisson, or binomial distributions) since the coefficient of variation ($\frac{\sigma^2}{\mu}$) for each item's half-week demand is greater than 1 [11].

Define the following. . .

$\mu \rightarrow$ the mean of the sample half-week demands divided by their standard package sizes
$\sigma^2 \rightarrow$ the variance of the sample half-week demands divided by their standard package sizes
$p \rightarrow$ the probability of success approximated as $p = \frac{\mu}{\sigma^2}$
$r \rightarrow$ a shape factor approximated as $r = \frac{\mu^2}{\sigma^2 - \mu}$
$k \rightarrow$ the number of failures before the rth success in a sequence of independent Bernoulli trials

The form of the negative binomial [10] that was used follows.

$$p(Y = k) = \frac{\prod_{j=0}^{k+1}(-r - j)}{k!} p^r (1 - p)^k \tag{5}$$

Notice that r is allowed to take on real values. This relaxed version allows for better fits than the unrelaxed distribution and is usually referred to as a generalized negative binomial distribution [3].

Chi-square goodness-of-fit tests unfortunately do not unanimously support the choice of distribution. Only 8 of the 14 A items and 5 of the 11 B items failed to reject the null

hypothesis at $\alpha = 0.01$ (critical value is 11.345 with 3 df)(attachment 10). One logical explanation is the erratic nature of the demand, which seems to prevent it from being modeled by any non-empirical distribution. Another explanation has to do with the structure of the tests. Using 6 intervals and having to estimate 2 distribution parameters leaves only 3 degrees of freedom to test the hypothesis. Having more intervals would increase the degrees of freedom and the critical chi-square value, possibly resulting in some rejection reversals. This, however, leads to manipulating the tests until the results are favorable, a time consuming and brow-raising activity.

The other initialization requirement for this heuristic is to have an EOQ value to work with for each item. Let K be the ordering cost, λ be the annual demand rate, I be the holding cost rate, and c be the standard cost for some item. The classic EOQ equation then [1], for the case where backorders are not allowed, is

$$EOQ = \sqrt{\frac{2K\lambda}{Ic}} \tag{6}$$

The value for λ can be estimated from the half-week demands in the sample. The c values are already provided. The values for K and I must be estimated since Quantegy was unable to provide such information.

Both [1] and [8] provide equations to estimate the ratio $\frac{K}{I}$ using exchange curves. This approach assumes that $\frac{K}{I}$ is constant across all items, which is not unreasonable. It also assumes a deterministic system where all items are being replenished with their EOQ values. Obviously this is not happening in reality. In fact most of the EOQ asumptions (i.e. no backorders, infinite production rates, constant and continuous demand, et cetera) are inappropriate here. But the EOQ value is just being used as an approximation for the supposed best value for $S - s$, the minimum order quantity in an (s, S) inventory control system. And making the EOQ assumptions incorporates each item's standard cost, something that Quantegy's current system ignores. This heuristic is just that: a heuristic. It does not claim

to provide optimal s and S values.

The exchange curve equation that relates the average number of orders per year over all n items (call it R) is the following [1] [8]. . .

$$R = \sqrt{\frac{I}{K}} \sum_{t=1}^{n} \sqrt{\frac{\lambda_t c_t}{2}} \tag{7}$$

To estimate R, simulate Quantegy's current policy over the sample set minus the first 13 weeks (used to initialize the demand forecasts) (attachment 11). $\hat{R}$ is the annualized total number of orders from these simlulations. Substitute this value into the equation above and solve for $\frac{K}{I}$ (attachment 12). The resulting value of $\frac{K}{I}$ is 19.535, implying that the ordering cost varies from \$1.95 to \$5.86 as the holding cost rate varies from 10% to 30%. EOQ values can now be calculated for every item (attachment 12).

The first stage can now begin. Define the following [14] . . .

$p_j \rightarrow$ P[one-period demand $= j$], defined by the distribution above, where $j = 0, 1, 2...$
$m(j) \rightarrow$ the expected number of visits to state $y - j$ until the next order, where $j = 0, 1, ...y - s - 1$
$M(j) \rightarrow$ the expected number of periods until the next order from state $s + j$, where $j = 1, ...S - s$

The relevant renewal equations for the first stage follow below.

$$m(j) = \sum_{l=0}^{j} p_l m(j - l) \tag{8}$$

$$M(j) = M(j - 1) + m(j - 1) \tag{9}$$

where $m(0) = \frac{1}{1-p_0}$ and $M(0) = 0$.

Recall that the first stage selects an $S - s$ value for each item by matching its EOQ value to the corresponding order quantity defined by the renewal equations. This latter value is defined as $M(S - s) * \mu$, the expected cycle length (time) multiplied by the mean demand

per period (quantity/time). To select the appropriate $S - s$ value, iterate through $M(j)$, starting at $M(0)$, until $M(j) \geq \frac{EOQ}{\mu}$. The resulting j value is $S - s$ for that item.

Define the following for the second stage [14] . . .

$\Delta \rightarrow$, the $S - s$ value found in the first stage
$L(y) \mid n \rightarrow$ the expected number of stockouts after n halfweeks given initial inventory position y
$H(s, y) \rightarrow$ the expected number of stockouts until the next order given initial inventory position y

The only additional renewal equation is the following.

$$H(s, y) = \sum_{j=0}^{y-s-1} m(j)[L(y - j \mid 2) - L(y - j \mid 1)] \tag{10}$$

Representing the loss function in the equation for $H(s, y)$ as a difference between the expected loss after 2 half-weeks (lagtime and review period) and the expected loss after 1 half-week (lagtime only) avoids the common mistake of double counting stockouts when the lagtime is not taken into account. Making the mistake leads to underestimating the true fillrate. This was pointed out by Johnson, et al. in their recent paper on the subject [4].

The second stage of this heuristic chooses the minimum $(s, s + \Delta)$ policy that meets the specified fillrate. Let β be the specified fillrate. It follows that the expected number of stockouts until the next order for a given policy that achieves the fillrate is $(1 - \beta) * M(\Delta) * \mu$. To select the appropriate policy, iterate through $H(s, s + \Delta)$, starting with $H(0, \Delta)$ until $H(s, s + \Delta) \leq (1 - \beta) * M(\Delta) * \mu$. The resulting policy is the solution.

The (s, S) values for each item that result from specifying 90%, 95%, and 99% fillrates are given in attachment 13. The simulated performance of these static policies over the ex post demands follows in the table below (attachment 14).

Performance Measure	$\beta = 90\%$	$\beta = 95\%$	$\beta = 99\%$
Total Orders	997	997	997
Avg OH Inv ($)	77,905.49	106,028.00	170,019.44
# Fillrates $\geq$ 90%	18	21	25
Avg Fillrate	92.7%	96.2%	99.1%

Table 3: Performance Comparison For Two-Stage Heuristic at Specified Fillrates

9 Alternative 3: An Almost-Exact Algorithm

The section details an algorithm that minimizes an (s, S) policy's average ordering and holding costs subject to a minimum expected fillrate constraint. It differs from the problem Zheng and Federgruen solved in [14] in that here the backlogging costs associated with a policy are ignored, essentially being replaced with the fillrate constraint.

Define the following. . .

$h \to$ the annual holding cost per unit
$K \to$ the fixed cost to place an order
$G(y) \to$ the one-period expected holding costs for a given policy when starting from inventory position y
$c(s, S) \to$ the long-run average cost for a given policy
$\beta(s, S) \to$ the expected fillrate for a given policy
$\bar{\beta} \to$ the minimum acceptable fillrate
$\bar{S} \to$ the upperbound on S, reflecting the storage capacity for the item at the location ordering it
$\bar{\Delta} \to$ the upperbound on $S - s$, reflecting the transportation capacity for the item on the vehicle delivering it

The relevant equations for the algorithm follow below.

$$G(y) = h * [S - y - (2\mu - L(S - y) \mid 2)] \tag{11}$$

$$c(s, S) = M(S - s)^{-1}[K + \sum_{j=0}^{S-s-1} m(j)G(j)] \tag{12}$$

$$\beta(s,S) = 1 - \frac{H(s,S)}{M(S-s)\mu} \tag{13}$$

The equation for $G(y)$ is specific for Quantegy's case where the lagtime is one period and the review interval is one period. It captures the cost of holding what should currently be on-hand $(S-y)$ minus the overshoot caused by the order placed a week prior $(2\mu - L(S-y) \mid 2)$. The equation for $c(s,S)$ can apply to any review interval/lagtime combination. The fillrate equation, when using the form of $H(s,y)$ already described, is only applicable for Quantegy's situation. The $m(j)$ and $M(j)$ values are the same ones used in the prior section.

The problem then is to minimize $c(s,S)$ subject to

$$\beta(s,S) \geq \bar{\beta}$$

$$S \leq \bar{S}$$

$$S - s \leq \bar{\Delta}$$

The following lemmas and theorems (proofs in attachment 15) guide the algorithm.

$(\beta(s,S) \leq \beta(s,S+1))$?

- **Lemma 1:** $\beta(s,S) \leq \beta(s+1,S)$
- **Lemma 2:** $\beta(s,S) \leq \beta(s+1,S+1)$
- **Lemma 3:** $c(s,S) \leq c(s+1,S)$
- **Lemma 4:** $c(s,S) \leq c(s+1,S+1)$
- **Theorem 1:** If (s^*, s^*+1) is the minimum feasible policy such that $\beta(s^*, s^*+1) \geq \bar{\beta}$, then all policies with $S < s^*$ are infeasible.
- **Theorem 2:** For every $\hat{S} \geq s^* + 1$ there is one $\hat{s}$ for which (a) all policies with $s < \hat{s}$ and $S \leq \hat{S}$ are infeasible and (b) all policies with $s > \hat{s}$ and $S \geq \hat{S}$ are dominated.

The algorithm simply searches each feasible S for the dominant s value that satisfies Theorem 2, keeping track of the minimum cost policy as it goes.

Exact (s, S) Algorithm

For every item. . .

- Search for the $(s^*, s^* + 1)$ policy defined by Theorem 1
- While $S \leq \bar{S}$
  - While $\beta(s, S) \geq \bar{\beta}$ and $s \geq S - \bar{\Delta}$
    - Decrement s
  - Increment s (become feasible again)
  - If $c(s, S)$ is less than the current minimum cost policy, then (s, S) is the new current minimum cost policy
  - Increment s and S

Like the values for K and h, the upperbounds $\bar{S}$ and $\bar{\Delta}$ are unknown. To accomodate this fact, the algorithm is modified to choose the first policy that is followed by 20 consecutive non-improving increments of S. This obviously no longer results in an optimal solution, since it is unknown whether policies more than twenty S values away have lower cost (hence the "Almost-Exact"). But the solutions appear to be optimal anyway because using a value of 200 instead of 20 did not result in any difference between the solutions. [The maximum number of states examined for each item was 2000.]

K was approximated from the $\frac{K}{I}$ value found in the prior section by assuming a holding cost rate (I) of 10%. The resulting K value is \$1.95. Using the same I value, h is approximated by the equation $h = Ic$, where c is each item's standard cost. It turns out that the algorithm is robust with respect to the choice of I, since the algorithm produced the same policies regardless of the I value used (non-zero of course). The specified fillrates again are 90%, 95%, and 99%. The specific policies that result from the algorithm are included in attachment 16. The simulated performance of the policies over the ex post set are summarized in the table below (attachment 17).

very low

Performance Measure	$\beta = 90\%$	$\beta = 95\%$	$\beta = 99\%$
Total Orders	1059	1066	1125
Avg OH Inv ($)	77,141.52	104,478.76	168,584.11
# Fillrates $\geq$ 90%	18	21	25
Avg Fillrate	92.4%	96.1%	99.0%

Table 4: Performance of Almost-Exact Alg. at Specified Fillrates

10 Recommendations and Conclusions

Croston's method was the clear winner of the forecasting alternatives. It resulted in fewer orders placed and superior fillrates than Quantegy's current method, all at a cost of a mere $40 increase in on-hand inventory. The naive method actually produced better fillrates than Croston's method, but had unacceptably high levels of on-hand inventory. The mean forecast just had deplorable fillrates. The resulting conclusion is that Quantegy should consider using a more sophisticated forecast than a 13-week moving average with their current system.

The renewal analysis approaches at $\beta = 90\%$ both produced results that were superior overall to Quantegy's current system. Both the two-stage heuristic and almost-exact policies had fewer orders, lower investments in on-hand inventory, and higher average fillrates. Increasing the specified fillrate to 95% and 99% predictably resulted in better fillrate performance, but pushed inventory costs to higher-than-current levels. As a result, no conclusions can be made with the 95% and 99% policies because of the subjective nature of the tradeoff between fillrates and holding costs. The 90% methods, on the other hand, appear to be clear recommendations to Quantegy's management, with the almost-exact policies barely edging out their two-stage heuristic competitors.

There is one drawback to these recommendations however. Quantegy's current simulated performance has all 14 of the A items, the most important, meeting at least a 90% fillrate. Both renewal analysis approaches, on the other hand, have only 8 of the 14 A items meeting a 90% fillrate. This may be unacceptable to Quantegy's service goals despite the overall

savings, depending on just how important the A items are.

The first intuitive explanation as to why this happens deals with the assumption of the underlying distritbution. Since the renewal analysis is only exact if the specified probability distribution is exact, it follows that the items that failed to meet 90% had incorrect distributions. The chi-square goodness-of-fit (GOF) tests, however, do not support this conclusion. Eight of the 14 A items "passed" their GOF tests with respect to the sample demands. Of these same 8, only 3 (A07, A08, A13) still "passed" with repsect to the ex post demands (attachment 18). Logically these 3 items should have met the 90% specified fillrate. But only A08 did so, with a 96.3% fillrate.

B item performance, on the other hand, is outstanding for the renewal analysis approaches. At $\beta = 90\%$, 10 of the 11 B items meet a 90% fillrate (B06). This is despite the fact that only 4 of the 11 B items "pass" the GOF test for the ex post demands. It seems that the accuracies of the simulated fillrates are unpredictable with respect to the GOF tests.

Perhaps the best method is a combination of both Croston's method and the almost-exact algorithm. Specifically the almost-exact algorithm should be used on any item that "passes" its GOF test over the sample set, still supporting the intuition above. The remaining items (A02-A05, A11, A14, B02, B04-B06, B08, B10) use the Croston alternative. The table below summarizes the simulated performance of such an approach (attachment 19). Here 10 of the 14 A items now meet the 90% requirement, which is an improvement over the 8 that result from renewal analysis alone. The investment in on-hand inventory is the second lowest so far. The number of orders is between that of Croston's method and the renewal analysis approaches. The fillrate performance is very competitive. Overall this approach appears to be a good compromise between the two methods. The ultimate decision on what tradeoff is best, however, and what approach to take is left to management.

A final word is in order about fairness. The renewal analysis policies would not be static in reality. The analysts at Quantegy would most likely update the policies monthly,

Performance Measure	Almost-Exact/Croston Hybrid
Total Orders	1100
Avg OH Inv ($)	67,956.66
# Fillrates $\geq$ 90%	17
Avg Fillrate	92.0%

Table 5: Performance of Almost-Exact/Croston Hybrid Approach

if not weekly, as new information came in. But the approach in this paper was to hold the renewal analysis policies constant for an entire year. There is no doubt that the simulated performance of these policies would have improved had the they been dynamic.

11 Tasks Before Sumbitting For Publication

The extension of [14] to include a service level constraint appears to be non-trivial. The main reason is that the upperbound on S that the authors present does not work when using a service level constraint, cutting off the optimal solution too soon in many cases. And the upperbounds presented in this paper ($\bar{S}$,$\bar{\Delta}$) are questionable both in their existence and availablilty. For example, does a storage limit really exist for any one individual item in a warehouse? If it did, how would you get that data? ?

As it stands now there are no formally proven upperbounds / stopping criteria for the almost-exact algorithm. The bound with the most promise appears to be the minimum $(1, S)$ policy such that $c(1, S) \geq c(s^*, s^* + 1)$, where s^* follows the notation in Theorem 1 above. Proving that $c(1, S + 1) \geq c(1, S)$ under these assumptions is turning out to be harder than expected. Once this is accomplished, then the same theorems that drive the algorithm will stop it, resulting in an algorithm that optimally solves the (s, S) problem subject to a fillrate constraint.

NP-hard?

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Attachments to Accompany "Designing an (s, S) Inventory Control System"

Gary Rafnson

18 July 1997

1. Raw Data
2. Example Plots of Raw Data
3. Outlier Adjustment Summary
4. Outlier Adjusted Data
5. Half-Week Demands
6. Simulation Results - Existing Policy
7. Initialized Croston's Method Parameters
8. Forecast Accuracies
9. Simulation Results - Naive / Mean / Croston Forecasts
10. Sample Set Goodness-of-Fit Tests
11. Simulation Results - Existing Policy Over Sample Set
12. Exchange Curve / EOQ Calculations
13. Two-Stage Heuristic Policies
14. Simulation Results - Two-Stage Heuristic
15. Proofs of Lemmas and Theorems
16. Almost-Exact Algorithm Policies
17. Simulation Results - Almost-Exact Algorithm
18. Ex Post Set Goodness-of-Fit Tests
19. Simulation Results - Almost-Exact/Croston Hybrid

Yr	Wk	A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	A12	A13	A14
Mean		1723.90	290.90	61.83	53.08	127.21	125.14	412.62	355.52	146.29	247.28	130.27	39.80	191.10	480.81
Standard Dev		1121.93	260.55	65.28	56.26	120.24	85.37	219.34	231.24	155.91	177.08	138.18	38.81	164.17	814.15
f		0.99	0.94	0.89	0.84	0.96	0.99	1.00	1.00	0.99	1.00	0.97	0.89	0.99	0.90
Std Package		10	10	5	5	10	10	10	10	10	1	2	7	7	10
93	22	900	160	40	0	70	40	230	30	780	217	170	7	126	0
93	23	2400	160	270	55	0	30	340	80	190	553	386	70	280	220
93	24	340	180	60	70	40	90	520	140	140	224	350	133	168	450
93	25	1920	540	135	60	20	160	300	150	120	994	660	0	343	390
93	26	880	60	195	50	20	100	380	220	40	49	238	0	112	550
93	27	1120	0	155	0	0	120	310	80	290	14	96	0	0	40
93	28	1300	320	115	55	130	50	310	70	280	994	338	224	7	0
93	29	1280	260	325	50	20	190	650	170	230	532	176	140	287	0
93	30	1340	380	230	60	40	80	150	100	150	70	138	63	70	40
93	31	2460	200	40	0	40	60	100	140	100	245	234	0	112	600
93	32	1140	240	235	45	10	20	240	130	450	154	80	0	0	170
93	33	260	140	100	55	300	10	230	40	90	609	190	0	203	0
93	34	1540	180	160	75	50	60	320	260	710	322	312	119	322	420
93	35	830	260	235	35	40	30	200	210	60	420	300	0	56	350
93	36	480	350	60	65	60	60	430	100	250	203	110	0	483	20
93	37	300	234	160	0	30	70	200	200	250	441	208	105	763	250
93	38	180	20	235	55	50	30	430	140	110	266	148	7	49	310
93	39	700	0	40	80	100	70	380	180	410	455	320	63	105	550
93	40	1000	0	30	30	60	100	550	320	80	224	94	7	70	300
93	41	1880	180	115	55	10	70	300	300	200	196	240	7	28	410
93	42	940	360	0	100	120	90	450	140	130	280	204	21	105	80
93	43	2660	280	90	100	120	80	260	340	200	546	234	14	42	400
93	44	1500	260	120	50	10	40	100	130	180	329	116	77	105	10
93	45	1180	480	20	90	90	130	320	280	220	315	212	7	77	620
93	46	900	240	130	15	40	90	440	260	160	231	316	7	98	60
93	47	0	60	220	200	130	170	190	220	10	224	50	112	63	480
93	48	1360	240	25	50	80	90	260	180	220	336	274	49	217	30
93	49	420	180	140	15	20	100	530	290	142	441	198	91	147	650
93	50	1100	180	45	85	10	100	310	260	90	203	174	56	280	100
93	51	980	440	30	55	100	120	200	430	1270	630	374	119	259	460
94	1	920	0	25	60	60	30	300	160	230	350	172	0	217	560
94	2	3820	20	65	55	110	40	510	890	250	161	156	112	189	230
94	3	700	0	10	55	0	10	380	200	100	154	192	35	77	50
94	4	720	200	120	65	180	250	390	390	150	483	160	70	189	650
94	5	1340	380	75	10	10	30	520	500	210	308	298	35	350	450
94	6	380	100	115	75	60	50	170	230	20	49	110	21	154	0
94	7	3260	200	65	60	340	140	520	670	110	203	150	7	133	410
94	8	1120	280	10	130	20	30	120	350	30	196	162	21	133	50
94	9	1040	260	420	0	130	60	250	160	200	322	228	56	315	630
94	10	1100	460	85	35	90	100	530	420	200	665	356	126	770	400
94	11	760	100	150	60	40	120	520	390	160	581	406	70	245	0
94	12	220	60	25	50	70	10	590	950	70	462	112	42	469	0
94	13	880	580	160	100	150	70	280	370	180	994	1230	49	763	1270
94	14	3180	0	55	65	80	20	360	190	260	70	62	0	175	50
94	15	1300	280	20	60	50	80	430	630	230	329	202	35	77	10
94	16	1820	0	40	120	110	60	290	320	60	140	116	84	301	1560
94	17	700	660	140	70	30	70	380	130	400	224	126	28	105	8020
94	18	560	260	85	170	50	40	360	220	30	84	98	7	154	100
94	19	1360	120	30	5	120	190	620	470	720	217	116	21	140	1180
94	20	600	200	10	60	40	110	320	190	200	406	112	7	175	480
94	21	2620	0	130	55	100	60	480	320	220	252	152	35	105	620
94	22	900	0	100	60	0	40	510	230	60	84	60	21	98	5260
94	23	860	140	65	50	90	100	620	290	100	154	198	0	133	690
94	24	960	100	20	0	170	140	390	550	170	413	146	7	119	3750
94	25	1400	300	21	285	40	100	704	1645	330	294	288	0	112	50
94	26	620	100	50	75	80	90	280	840	200	308	200	28	133	340
94	27	3060	160	10	0	0	0	370	580	0	91	44	21	14	600
94	28	1100	420	35	35	50	50	400	290	140	147	74	14	147	910

Raw Data - A Items

94	29	460	40	15	150	80	70	220	220	190	238	172	14	161	100
94	30	1060	240	15	100	60	90	600	650	160	133	122	21	119	550
94	31	2060	220	0	5	60	60	290	270	100	210	126	84	133	180
94	32	1660	200	145	75	170	70	430	350	180	168	84	28	133	360
94	33	620	20	75	65	50	20	130	240	230	322	206	49	126	450
94	34	920	320	80	25	140	140	420	380	160	560	96	7	210	610
94	35	1140	140	110	95	80	80	470	460	150	224	114	0	266	60
94	36	1240	20	0	5	20	100	280	270	200	105	52	28	259	300
94	37	3020	280	20	170	140	90	700	460	150	308	180	14	273	410
94	38	520	100	30	110	100	70	220	400	150	189	82	28	91	940
94	39	1060	260	50	100	60	10	330	450	190	245	160	112	196	30
94	40	2360	140	35	0	130	120	260	220	70	119	90	42	168	400
94	41	1420	40	100	145	200	60	530	560	110	224	124	21	70	50
94	42	2940	440	10	20	130	150	380	630	180	231	164	63	217	260
94	43	1420	340	115	80	200	240	340	530	160	245	106	28	266	400
94	44	2560	280	60	60	0	180	590	510	40	112	134	7	112	430
94	45	740	640	50	400	190	180	420	510	310	371	128	0	238	120
94	46	1040	360	10	60	180	60	550	540	140	161	144	14	98	540
94	47	2840	360	10	20	200	80	120	220	150	168	148	49	119	500
94	48	1140	380	45	60	183	183	765	380	180	854	178	14	994	500
94	49	1240	400	60	60	10	130	460	400	610	301	332	42	196	0
94	50	1280	280	0	20	190	220	250	810	90	392	120	7	147	70
94	51	2080	600	170	50	150	230	690	665	330	707	720	140	700	480
95	1	1820	160	80	10	780	140	150	410	40	140	88	42	70	610
95	2	1680	40	60	0	110	200	370	360	130	119	32	28	112	500
95	3	2080	540	0	10	50	100	490	550	40	168	70	35	35	0
95	4	3180	480	35	35	120	90	400	820	140	189	26	21	56	130
95	5	560	240	25	70	60	160	840	460	470	294	106	0	119	500
95	6	1620	40	10	110	30	180	540	330	40	70	110	7	140	320
95	7	980	220	70	20	20	10	440	640	60	287	172	7	119	460
95	8	1540	260	10	60	87	60	190	440	90	119	62	21	161	190
95	9	3440	200	145	5	120	160	400	520	140	245	160	35	56	960
95	10	780	300	45	80	170	110	250	450	220	252	186	56	182	370
95	11	3640	100	50	30	120	100	480	390	50	189	122	119	231	60
95	12	1740	140	70	90	110	140	540	490	10	189	110	7	126	1010
95	13	4260	420	25	90	260	300	340	400	90	168	162	14	217	90
95	14	740	100	50	30	180	120	510	70	130	175	108	28	154	510
95	15	1020	420	0	55	160	60	390	430	20	245	124	35	154	410
95	16	1520	240	0	10	40	90	520	240	40	231	158	21	196	400
95	17	1060	240	65	110	70	110	330	430	50	105	160	0	168	280
95	18	3240	520	20	95	110	110	410	770	100	525	246	35	273	420
95	19	1620	340	70	10	380	310	790	390	30	364	220	112	189	460
95	20	4160	140	40	60	150	180	540	270	40	280	178	21	63	680
95	21	1060	120	20	0	200	240	1100	1210	60	175	24	28	861	60
95	22	160	400	84	100	50	110	400	320	650	532	0	7	641	100
95	23	2320	180	25	10	170	200	540	200	30	196	0	14	217	1040
95	24	1480	200	90	90	140	80	400	50	60	77	34	49	77	430
95	25	3980	80	30	60	210	110	480	110	40	112	10	35	91	70
95	26	3040	200	0	30	150	110	700	290	150	252	0	91	147	560
95	27	740	80	55	55	0	30	200	100	20	98	0	0	42	200
95	28	1220	120	20	125	220	350	770	170	70	231	10	56	77	610
95	29	1540	200	30	55	20	100	490	150	60	203	8	7	14	200
95	30	1860	520	80	0	160	170	272	135	130	238	10	56	42	550
95	31	1300	250	25	125	280	330	500	520	40	112	8	84	126	550
95	32	3760	200	35	20	150	160	430	560	100	63	28	49	119	460
95	33	1580	260	15	60	10	40	480	220	90	84	32	14	245	350
95	34	2740	260	15	115	40	90	310	370	40	203	14	42	189	180
95	35	1280	520	90	55	110	150	420	310	40	49	0	21	35	460
95	36	2440	580	50	110	80	120	330	480	30	259	24	49	196	0
95	37	1380	240	35	5	50	110	200	140	30	210	6	35	238	450
95	38	2620	220	0	55	140	200	520	510	150	329	54	14	70	470
95	39	1340	680	50	60	70	140	540	630	20	63	32	42	98	80
95	40	2500	140	0	0	60	50	520	670	110	140	44	42	56	580
95	41	1200	500	35	90	90	90	230	440	70	210	34	56	98	540

95	42	2980	140	80	25	90	210	580	300	90	189	82	14	35	400
95	43	3160	620	20	130	100	210	260	630	130	210	92	49	658	150
95	44	4600	1100	65	0	50	100	480	920	50	231	52	21	154	0
95	45	1700	200	25	10	170	80	300	400	180	385	82	35	392	600
95	46	2840	180	10	10	110	180	620	740	90	315	2	91	385	800
95	47	780	280	10	0	120	160	200	140	140	350	130	35	252	80
95	48	2960	480	30	60	20	200	190	290	250	602	130	35	686	520
95	49	660	0	95	5	80	90	220	420	10	70	16	7	112	410
95	50	360	20	80	155	110	120	230	200	70	140	56	28	105	420
95	51	2360	740	5	260	250	170	980	430	50	203	36	28	42	450
96	1	400	260	0	0	60	90	800	270	30	42	16	7	35	400
96	2	940	140	0	10	20	0	220	30	60	245	26	42	175	0
96	3	3600	60	25	5	160	160	870	170	20	56	24	77	112	520
96	4	2700	860	30	110	90	320	420	320	70	98	40	70	56	400
96	5	1620	480	20	35	200	130	1020	290	60	301	12	14	161	490
96	6	2340	120	135	5	140	130	330	420	80	84	16	56	105	650
96	7	820	240	75	85	120	90	140	200	40	126	40	84	49	0
96	8	540	220	55	60	120	200	380	220	90	63	30	14	63	480
96	9	3020	380	0	40	60	70	160	500	30	147	62	7	133	0
96	10	3460	440	30	175	180	220	340	430	160	175	42	35	105	590
96	11	2480	260	15	10	140	110	300	130	10	119	56	28	203	400
96	12	3340	600	40	75	50	70	240	330	60	91	10	49	168	410
96	13	2940	220	50	5	220	150	310	460	150	252	48	63	147	3130
96	14	2580	300	0	15	130	90	420	430	60	105	44	7	77	550
96	15	2540	560	10	0	150	170	270	140	80	245	118	119	126	60
96	16	1620	0	60	0	130	330	600	170	80	63	96	49	210	450
96	17	2760	920	30	20	220	190	290	320	160	245	124	7	245	0
96	18	900	60	50	0	140	60	270	100	120	147	46	133	203	500
96	19	2600	140	10	5	290	120	400	280	20	70	12	7	196	980
96	20	1320	160	0	5	150	450	270	260	80	147	122	84	182	480
96	21	3640	860	65	20	120	350	170	190	60	133	30	49	182	490
96	22	2380	320	10	10	300	210	510	200	180	119	26	14	154	400
96	23	600	60	15	0	160	220	250	160	80	196	70	21	175	10
96	24	3520	780	45	80	450	180	530	220	80	224	108	168	238	720
96	25	1460	300	0	0	310	200	180	420	60	63	64	42	238	420
96	26	1060	540	20	5	280	50	540	240	230	315	108	42	371	520
96	27	3280	40	0	0	70	100	150	203	20	28	8	0	35	50
96	28	1480	240	105	15	180	50	310	380	20	126	88	42	182	980
96	29	1700	60	100	15	530	120	830	220	80	175	96	119	231	0
96	30	1840	360	30	20	260	180	370	550	80	168	156	35	273	420
96	31	1140	280	105	0	550	140	440	230	100	210	56	21	497	70
96	32	2640	980	35	0	360	150	620	310	120	161	52	28	154	900
96	33	680	260	10	0	130	220	350	400	60	224	74	7	287	0
96	34	2200	440	80	25	180	170	520	250	100	196	92	70	287	170
96	35	5660	360	0	10	210	140	270	381	170	84	34	0	175	840
96	36	1300	40	0	10	160	150	380	170	170	280	44	49	224	700
96	37	1400	780	80	0	460	280	510	510	70	147	34	35	266	450
96	38	820	660	35	0	200	541	410	110	100	252	132	21	259	400
96	39	6900	1740	80	0	750	360	1970	1100	50	217	22	70	189	120
96	40	2260	1600	15	10	20	160	130	230	80	63	30	21	119	400

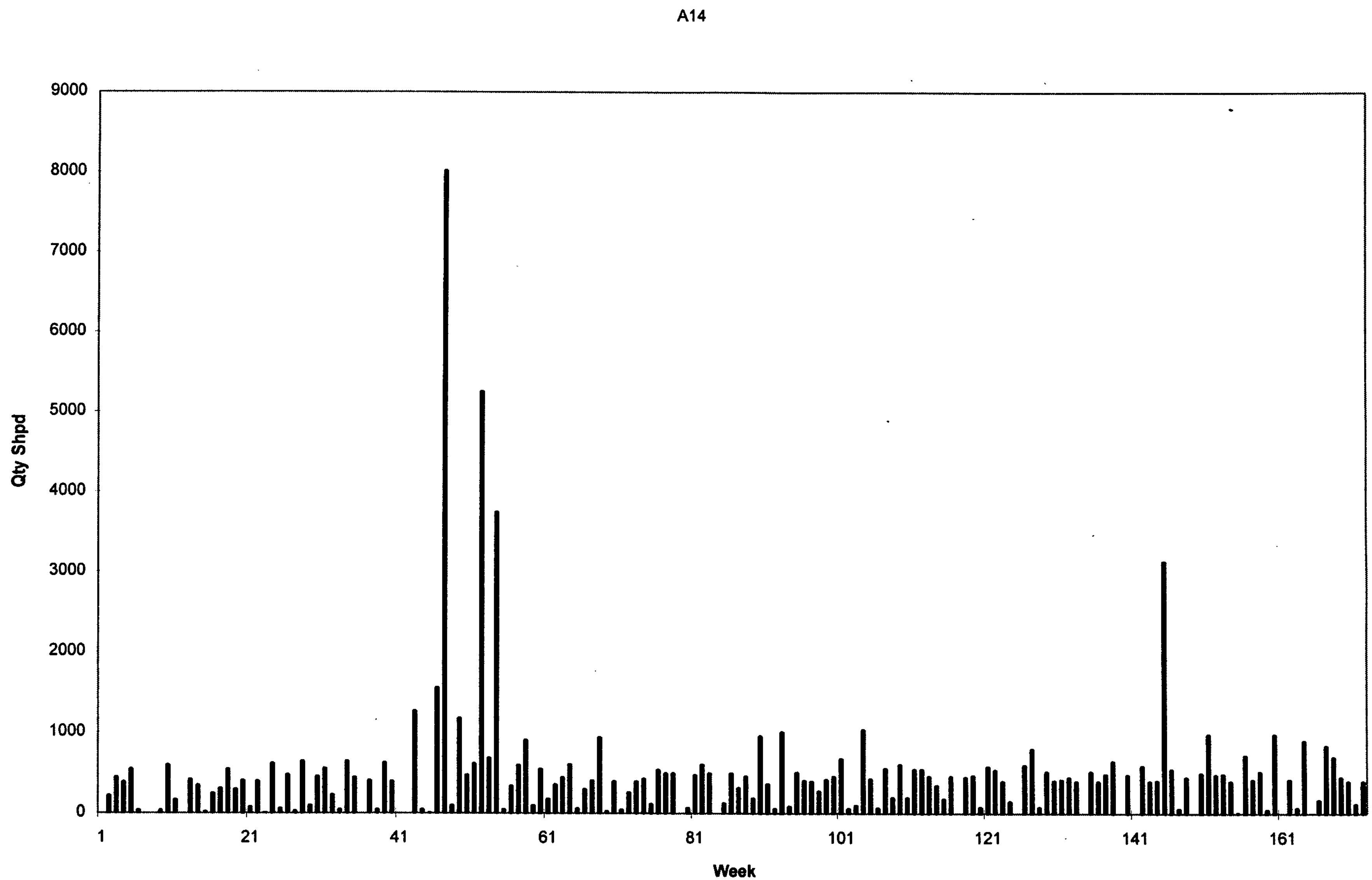
Yr	Wk	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B12
	Mean	81.56	19.45	77.99	3.62	97.62	62.23	29.48	163.60	21.33	71.51	20.29
	Standard Dev	83.11	27.89	105.28	11.34	122.60	63.35	46.92	136.70	58.95	117.84	55.15
	f	0.93	0.69	0.84	0.30	0.88	0.86	0.67	0.97	0.24	0.38	0.27
	Std Package	10	5	10	1	10	10	10	2	40	20	5
93	22	50	5	20	0	80	60	0	164	0	0	60
93	23	170	35	150	4	90	90	110	270	0	440	70
93	24	120	0	410	4	0	100	140	498	0	0	225
93	25	70	55	140	128	120	100	30	84	0	40	25
93	26	180	35	80	0	310	0	20	0	80	0	40
93	27	40	50	10	0	100	10	0	0	0	160	25
93	28	80	25	80	0	120	180	20	202	0	0	0
93	29	130	40	130	0	10	80	20	334	0	360	0
93	30	80	10	238	4	50	150	210	198	0	0	25
93	31	20	25	750	0	0	10	200	242	0	0	0
93	32	50	65	30	0	8	60	0	72	80	200	0
93	33	30	5	0	0	0	0	0	524	0	0	0
93	34	170	35	0	8	0	0	10	112	0	0	0
93	35	20	10	0	0	0	0	0	220	0	0	0
93	36	0	20	0	0	0	13	0	302	0	600	0
93	37	8	10	0	0	0	0	80	100	0	0	0
93	38	0	0	0	0	19	520	0	64	0	0	0
93	39	0	40	0	0	0	100	260	110	0	480	0
93	40	420	15	0	0	0	60	0	130	0	0	0
93	41	40	35	0	0	0	10	50	114	0	0	0
93	42	130	20	520	12	460	40	320	138	0	0	0
93	43	30	50	150	0	100	0	50	250	0	320	0
93	44	40	25	40	0	190	20	0	104	0	0	0
93	45	90	5	110	20	120	30	20	238	0	0	0
93	46	80	125	160	0	110	20	0	122	280	0	0
93	47	30	30	20	0	1000	10	0	86	0	0	0
93	48	90	15	90	0	30	70	0	290	0	0	0
93	49	190	20	50	0	70	10	10	166	0	160	0
93	50	80	0	10	0	90	50	30	212	0	80	0
93	51	100	50	260	20	170	0	90	196	0	360	0
94	1	210	15	80	0	60	40	10	256	0	0	0
94	2	190	10	130	0	230	60	30	220	0	360	0
94	3	20	25	50	25	70	50	0	194	0	200	0
94	4	440	20	40	0	60	40	0	110	0	0	0
94	5	120	30	100	0	180	230	50	334	0	160	20
94	6	50	0	30	0	120	20	10	82	0	0	0
94	7	80	20	80	0	40	130	140	260	80	80	0
94	8	40	0	50	0	70	0	30	184	80	0	0
94	9	20	0	80	0	240	60	10	282	0	320	20
94	10	60	45	160	0	80	50	50	458	0	0	0
94	11	90	10	100	8	100	90	30	206	0	0	30
94	12	240	10	50	0	60	80	20	640	0	0	0
94	13	40	20	40	0	60	60	40	968	0	0	20
94	14	190	100	140	0	90	0	10	90	0	240	0
94	15	420	10	10	0	30	60	20	160	40	0	20
94	16	40	0	40	8	70	20	10	92	0	0	0
94	17	80	120	100	0	190	20	100	156	0	0	20
94	18	20	10	180	24	130	70	0	120	0	160	0
94	19	160	0	120	0	60	0	20	158	0	120	0
94	20	140	10	10	0	0	70	0	194	80	160	10
94	21	50	15	160	0	80	70	40	144	0	40	0
94	22	190	0	30	0	20	0	0	94	0	200	0
94	23	200	40	100	0	30	70	10	146	0	80	0
94	24	50	0	50	0	90	10	0	262	0	319	0
94	25	80	35	220	0	84	70	40	202	0	0	0

94	26	0	25	20	0	300	80	10	178	160	160	0
94	27	30	0	30	0	0	40	0	44	0	0	100
94	28	20	35	350	0	110	30	140	114	0	120	0
94	29	110	20	80	0	40	30	0	106	40	0	10
94	30	240	5	140	0	180	60	10	200	0	160	200
94	31	160	120	110	0	50	40	0	200	40	120	0
94	32	90	10	100	0	220	70	0	194	80	0	260
94	33	70	80	150	0	70	20	20	262	0	0	10
94	34	130	140	60	0	0	100	0	130	40	200	0
94	35	80	15	250	0	60	50	10	278	80	160	0
94	36	10	0	80	0	20	10	10	102	0	0	30
94	37	50	5	160	0	30	90	90	164	0	240	300
94	38	130	60	120	0	30	40	0	144	0	0	0
94	39	20	0	100	8	290	30	50	246	0	0	0
94	40	70	10	50	0	60	110	70	96	0	0	5
94	41	20	0	120	0	70	20	0	104	0	120	0
94	42	170	35	110	0	10	40	60	124	40	320	5
94	43	80	35	10	0	50	60	30	280	0	160	120
94	44	130	5	70	0	20	30	40	274	80	0	0
94	45	190	125	60	0	0	0	110	316	40	0	0
94	46	80	10	40	16	50	90	10	216	0	320	0
94	47	0	5	20	0	620	90	0	176	0	0	0
94	48	10	25	20	4	500	20	30	252	0	0	0
94	49	120	5	10	8	0	30	10	502	40	0	0
94	50	60	60	80	0	60	20	10	870	0	120	0
94	51	40	25	30	0	140	0	0	604	0	0	0
95	1	90	135	70	0	340	30	20	104	560	0	325
95	2	100	10	120	0	120	50	90	98	0	0	0
95	3	50	25	0	0	30	110	20	122	0	0	0
95	4	80	5	20	0	120	20	0	118	108	0	0
95	5	20	40	110	0	90	40	0	126	0	0	0
95	6	200	25	230	0	230	70	30	92	0	0	15
95	7	40	50	30	10	140	40	20	204	0	0	0
95	8	10	25	0	24	20	0	0	130	0	0	230
95	9	290	25	280	24	110	30	100	182	120	0	90
95	10	20	30	20	4	80	70	0	222	0	160	0
95	11	160	25	40	0	70	20	10	178	80	0	0
95	12	40	25	240	0	140	80	10	142	0	40	0
95	13	40	10	60	0	170	10	10	242	160	0	200
95	14	50	10	0	20	30	50	40	218	0	80	25
95	15	60	20	170	8	60	80	70	114	0	0	0
95	16	70	0	80	8	100	0	10	230	0	0	0
95	17	80	5	20	0	80	0	20	220	40	200	0
95	18	10	5	40	0	50	80	20	282	0	0	0
95	19	40	50	80	0	140	60	10	164	40	0	0
95	20	240	35	110	8	150	0	80	252	0	160	100
95	21	20	0	60	0	20	30	20	212	0	160	0
95	22	110	0	40	0	140	50	40	160	0	0	0
95	23	80	30	20	4	310	0	0	34	0	40	0
95	24	80	20	0	0	10	70	40	24	0	40	0
95	25	20	0	200	8	60	20	40	24	40	0	0
95	26	40	110	40	0	170	130	10	36	0	160	50
95	27	20	5	0	0	0	0	0	0	40	0	0
95	28	30	0	50	0	50	50	0	68	40	0	0
95	29	50	0	60	4	20	70	0	0	80	400	0
95	30	300	15	10	0	10	10	60	0	0	0	0
95	31	0	0	60	0	70	60	0	2	0	0	0
95	32	40	5	50	8	30	60	60	46	0	0	0
95	33	40	0	20	0	50	20	20	54	40	0	0
95	34	50	0	0	0	20	20	10	0	0	0	0
95	35	20	0	50	18	10	30	0	88	0	0	0

95	36	40	20	30	4	70	70	70	110	0	240	10
95	37	20	40	120	4	0	140	0	76	0	0	0
95	38	10	0	0	0	110	20	70	76	0	160	10
95	39	130	20	80	0	160	50	10	60	0	0	0
95	40	150	0	10	0	110	60	10	90	40	0	0
95	41	0	0	0	0	120	20	10	56	40	120	5
95	42	70	0	0	4	520	10	50	94	0	0	0
95	43	120	5	130	4	100	70	20	208	0	160	40
95	44	160	0	50	0	30	50	10	34	240	0	0
95	45	50	15	0	0	90	90	50	66	0	440	30
95	46	40	5	0	0	60	20	20	6	0	80	200
95	47	120	10	100	0	0	50	0	36	80	0	0
95	48	50	5	190	4	170	20	10	390	0	0	0
95	49	10	0	30	0	110	0	20	32	0	0	0
95	50	30	30	0	12	50	0	0	66	0	0	0
95	51	370	0	160	0	210	0	10	54	0	0	0
96	1	50	0	60	4	30	90	140	32	0	0	0
96	2	30	20	20	8	10	0	0	64	0	0	0
96	3	30	20	20	12	0	130	20	30	0	120	0
96	4	0	5	20	12	10	50	10	30	40	0	0
96	5	100	0	10	4	80	130	30	42	0	0	15
96	6	60	25	50	12	80	190	0	28	0	0	50
96	7	0	0	0	0	50	60	20	66	0	0	0
96	8	30	0	400	0	90	200	0	48	0	120	0
96	9	60	10	10	0	100	150	0	80	0	0	50
96	10	90	0	10	0	20	150	40	80	0	120	0
96	11	70	0	20	4	170	100	10	112	0	0	0
96	12	50	0	30	0	50	90	0	54	0	120	0
96	13	20	5	30	0	70	230	10	134	80	40	0
96	14	10	0	110	3	40	50	10	162	40	0	0
96	15	20	20	30	0	40	10	100	74	0	40	0
96	16	30	0	10	1	440	170	20	136	0	80	35
96	17	10	5	30	4	50	60	10	168	0	80	0
96	18	100	0	40	0	90	140	0	94	0	40	0
96	19	80	20	10	4	0	80	0	172	0	0	0
96	20	50	0	20	4	200	70	20	226	80	0	0
96	21	50	10	0	0	70	40	10	150	0	160	5
96	22	100	10	0	0	30	60	0	158	0	0	0
96	23	10	0	60	0	110	180	0	134	0	0	100
96	24	40	0	50	0	50	190	20	186	0	0	0
96	25	60	5	20	0	50	10	20	90	0	160	105
96	26	80	0	70	4	50	110	40	240	80	0	0
96	27	120	0	10	0	50	0	0	60	0	0	0
96	28	20	5	10	0	140	150	100	124	0	0	0
96	29	0	0	0	5	70	50	0	92	0	0	0
96	30	30	0	20	0	120	100	0	144	0	0	0
96	31	190	0	50	0	60	110	10	258	0	0	0
96	32	360	5	20	0	20	120	30	150	40	300	0
96	33	50	5	50	5	100	140	0	112	0	120	0
96	34	70	5	40	0	0	120	0	176	0	320	0
96	35	30	10	66	40	120	200	20	134	0	0	55
96	36	20	0	0	0	60	70	20	138	160	0	0
96	37	40	0	130	0	110	160	20	194	0	0	95
96	38	0	0	40	0	40	200	0	172	40	0	0
96	39	40	0	600	15	280	40	70	142	0	0	0
96	40	0	15	0	0	20	10	0	82	0	0	0

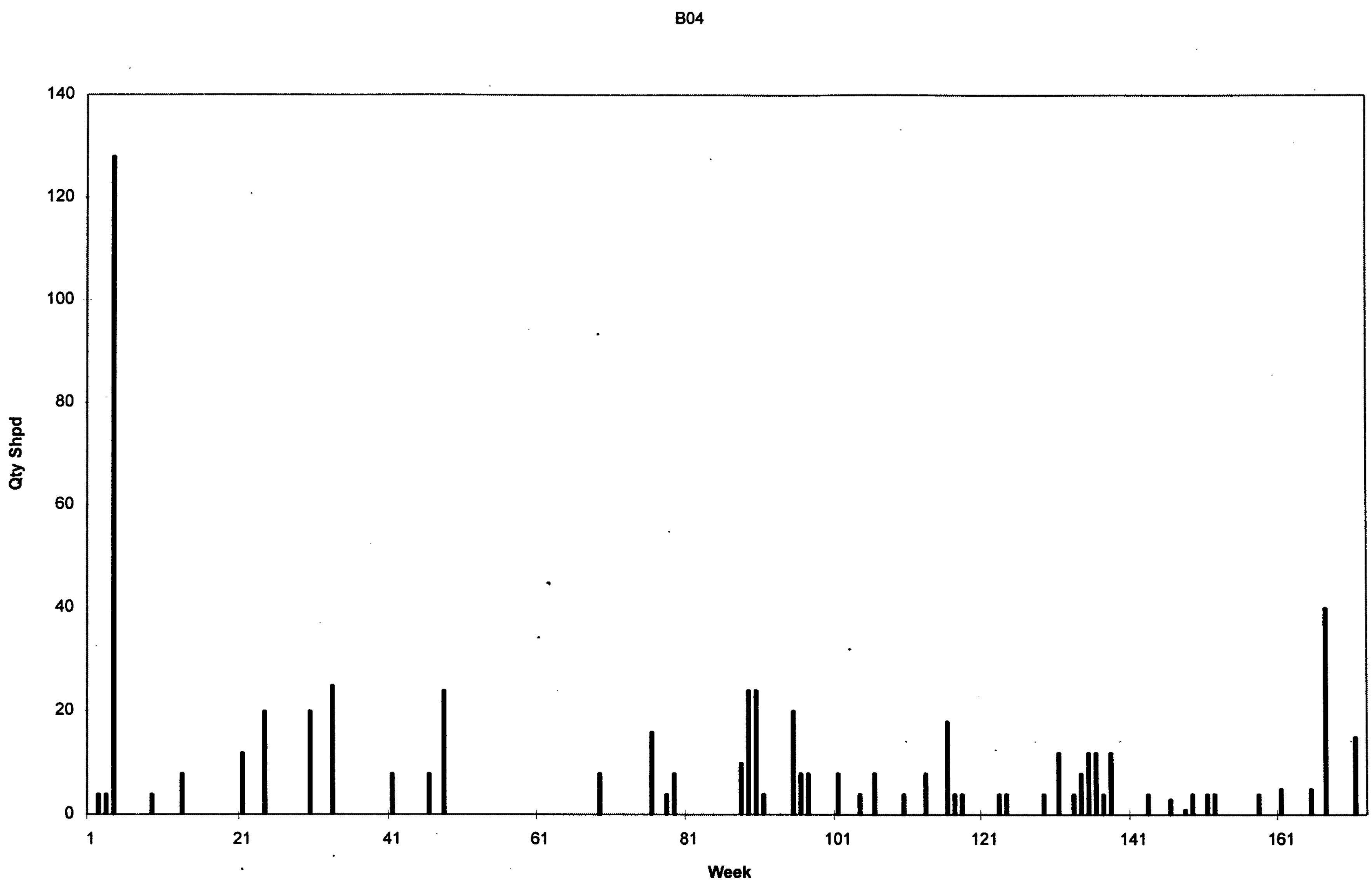
Attachment 2

Raw Weekly Demand - Item A14



Attachment 2

Raw Weekly Demand - Item B04



Outlier Adjustment Summary

Attachment 3

	Outlier Lower Bound (Mean+3StdDev)	Obs > Lower Bound (Year \ Week)	Replacement Value (Rounded Mean)
A01	5089.68	96\35,39	1720
A02	1072.54	95\44 96\39,40	300
A03	257.66	93\23,29 94\9	60
A04	221.85	94\25,45 95\51	55
A05	487.94	95\1 96\29,31,39	130
A06	381.25	96\20,38	130
A07	1070.65	95\21 96\39	410
A08	1049.24	94\25 95\21 96\39	360
A09	614.02	93\22,34,51 94\19,22	150
A10	778.52	93\25,28 94\13,48	247
A11	544.81	93\25 94\13,51	130
A12	156.22	93\28 96\24	42
A13	683.60	93\37 94\10,13,48,51 95\21,48	189
A14	2923.27	94\17,22,24 96\13	480
B01	330.89	93\40 94\4,15 95\51 96\32	80
B02	103.11	93\46 94\17,31,34,45 95\1,26	20
B03	393.83	93\24,31,42 96\8,39	80
B04	37.63	93\25 96\34	4
B05	465.43	93\47 94\47,48 95\42	100
B06	252.28	93\38	60
B07	170.24	93\30,31,39,42	30
B08	573.70	94\12,13,50,51	164
B09	198.18	93\46 95\1,44	40
B10	425.04	93\23,36,39 95\45	80
B12	185.75	93\24 94\30,32,37 95\1,8,13,46	20

Outlier Adjusted Data - A Items

Attachment 4

Yr	Wk	A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	A12	A13	A14
	Mean	1670.87	270.14	56.98	48.55	115.06	120.89	399.54	338.80	126.64	230.72	117.36	38.01	166.60	374.77
	Standard Dev	1004.30	203.28	53.19	43.31	86.92	75.11	176.05	189.62	94.45	138.37	90.44	34.76	105.93	286.40
	f	0.99	0.94	0.89	0.84	0.96	0.99	1.00	1.00	0.99	1.00	0.97	0.89	0.99	0.90
	Std Package	10	10	5	5	10	10	10	10	10	1	2	7	7	10
93	22	900	160	40	0	70	40	230	30	150	217	170	7	126	0
93	23	2400	160	60	55	0	30	340	80	190	553	386	70	280	220
93	24	340	180	60	70	40	90	520	140	140	224	350	133	168	450
93	25	1920	540	135	60	20	160	300	150	120	247	130	0	343	390
93	26	880	60	195	50	20	100	380	220	40	49	238	0	112	550
93	27	1120	0	155	0	0	120	310	80	290	14	96	0	0	40
93	28	1300	320	115	55	130	50	310	70	280	247	338	42	7	0
93	29	1280	260	60	50	20	190	650	170	230	532	176	140	287	0
93	30	1340	380	230	60	40	80	150	100	150	70	138	63	70	40
93	31	2460	200	40	0	40	60	100	140	100	245	234	0	112	600
93	32	1140	240	235	45	10	20	240	130	450	154	80	0	0	170
93	33	260	140	100	55	300	10	230	40	90	609	190	0	203	0
93	34	1540	180	160	75	50	60	320	260	150	322	312	119	322	420
93	35	830	260	235	35	40	30	200	210	60	420	300	0	56	350
93	36	480	350	60	65	60	60	430	100	250	203	110	0	483	20
93	37	300	234	160	0	30	70	200	200	250	441	208	105	189	250
93	38	180	20	235	55	50	30	430	140	110	266	148	7	49	310
93	39	700	0	40	80	100	70	380	180	410	455	320	63	105	550
93	40	1000	0	30	30	60	100	550	320	80	224	94	7	70	300
93	41	1880	180	115	55	10	70	300	300	200	196	240	7	28	410
93	42	940	360	0	100	120	90	450	140	130	280	204	21	105	80
93	43	2660	280	90	100	120	80	260	340	200	546	234	14	42	400
93	44	1500	260	120	50	10	40	100	130	180	329	116	77	105	10
93	45	1180	480	20	90	90	130	320	280	220	315	212	7	77	620
93	46	900	240	130	15	40	90	440	260	160	231	316	7	98	60
93	47	0	60	220	200	130	170	190	220	10	224	50	112	63	480
93	48	1360	240	25	50	80	90	260	180	220	336	274	49	217	30
93	49	420	180	140	15	20	100	530	290	142	441	198	91	147	650
93	50	1100	180	45	85	10	100	310	260	90	203	174	56	280	100
93	51	980	440	30	55	100	120	200	430	150	630	374	119	259	460
94	1	920	0	25	60	60	30	300	160	230	350	172	0	217	560
94	2	3820	20	65	55	110	40	510	890	250	161	156	112	189	230
94	3	700	0	10	55	0	10	380	200	100	154	192	35	77	50
94	4	720	200	120	65	180	250	390	390	150	483	160	70	189	650
94	5	1340	380	75	10	10	30	520	500	210	308	298	35	350	450
94	6	380	100	115	75	60	50	170	230	20	49	110	21	154	0
94	7	3260	200	65	60	340	140	520	670	110	203	150	7	133	410
94	8	1120	280	10	130	20	30	120	350	30	196	162	21	133	50
94	9	1040	260	60	0	130	60	250	160	200	322	228	56	315	630
94	10	1100	460	85	35	90	100	530	420	200	665	356	126	189	400
94	11	760	100	150	60	40	120	520	390	160	581	406	70	245	0
94	12	220	60	25	50	70	10	590	950	70	462	112	42	469	0
94	13	880	580	160	100	150	70	280	370	180	247	130	49	189	1270
94	14	3180	0	55	65	80	20	360	190	260	70	62	0	175	50
94	15	1300	280	20	60	50	80	430	630	230	329	202	35	77	10
94	16	1820	0	40	120	110	60	290	320	60	140	116	84	301	1560
94	17	700	660	140	70	30	70	380	130	400	224	126	28	105	480
94	18	560	260	85	170	50	40	360	220	30	84	98	7	154	100
94	19	1360	120	30	5	120	190	620	470	150	217	116	21	140	1180
94	20	600	200	10	60	40	110	320	190	200	406	112	7	175	480
94	21	2620	0	130	55	100	60	480	320	220	252	152	35	105	620
94	22	900	0	100	60	0	40	510	230	60	84	60	21	98	480
94	23	860	140	65	50	90	100	620	290	100	154	198	0	133	690
94	24	960	100	20	0	170	140	390	550	170	413	146	7	119	480
94	25	1400	300	21	55	40	100	704	360	330	294	288	0	112	50
94	26	620	100	50	75	80	90	280	840	200	308	200	28	133	340
94	27	3060	160	10	0	0	0	370	580	0	91	44	21	14	600
94	28	1100	420	35	35	50	50	400	290	140	147	74	14	147	910

94	29	460	40	15	150	80	70	220	220	190	238	172	14	161	100
94	30	1060	240	15	100	60	90	600	650	160	133	122	21	119	550
94	31	2060	220	0	5	60	60	290	270	100	210	126	84	133	180
94	32	1660	200	145	75	170	70	430	350	180	168	84	28	133	360
94	33	620	20	75	65	50	20	130	240	230	322	206	49	126	450
94	34	920	320	80	25	140	140	420	380	160	560	96	7	210	610
94	35	1140	140	110	95	80	80	470	460	150	224	114	0	266	60
94	36	1240	20	0	5	20	100	280	270	200	105	52	28	259	300
94	37	3020	280	20	170	140	90	700	460	150	308	180	14	273	410
94	38	520	100	30	110	100	70	220	400	150	189	82	28	91	940
94	39	1060	260	50	100	60	10	330	450	190	245	160	112	196	30
94	40	2360	140	35	0	130	120	260	220	70	119	90	42	168	400
94	41	1420	40	100	145	200	60	530	560	110	224	124	21	70	50
94	42	2940	440	10	20	130	150	380	630	180	231	164	63	217	260
94	43	1420	340	115	80	200	240	340	530	160	245	106	28	266	400
94	44	2560	280	60	60	0	180	590	510	40	112	134	7	112	430
94	45	740	640	50	55	190	180	420	510	310	371	128	0	238	120
94	46	1040	360	10	60	180	60	550	540	140	161	144	14	98	540
94	47	2840	360	10	20	200	80	120	220	150	168	148	49	119	500
94	48	1140	380	45	60	183	183	765	380	180	247	178	14	189	500
94	49	1240	400	60	60	10	130	460	400	610	301	332	42	196	0
94	50	1280	280	0	20	190	220	250	810	90	392	120	7	147	70
94	51	2080	600	170	50	150	230	690	665	330	707	130	140	189	480
95	1	1820	160	80	10	130	140	150	410	40	140	88	42	70	610
95	2	1680	40	60	0	110	200	370	360	130	119	32	28	112	500
95	3	2080	540	0	10	50	100	490	550	40	168	70	35	35	0
95	4	3180	480	35	35	120	90	400	820	140	189	26	21	56	130
95	5	560	240	25	70	60	160	840	460	470	294	106	0	119	500
95	6	1620	40	10	110	30	180	540	330	40	70	110	7	140	320
95	7	980	220	70	20	20	10	440	640	60	287	172	7	119	460
95	8	1540	260	10	60	87	60	190	440	90	119	62	21	161	190
95	9	3440	200	145	5	120	160	400	520	140	245	160	35	56	960
95	10	780	300	45	80	170	110	250	450	220	252	186	56	182	370
95	11	3640	100	50	30	120	100	480	390	50	189	122	119	231	60
95	12	1740	140	70	90	110	140	540	490	10	189	110	7	126	1010
95	13	4260	420	25	90	260	300	340	400	90	168	162	14	217	90
95	14	740	100	50	30	180	120	510	70	130	175	108	28	154	510
95	15	1020	420	0	55	160	60	390	430	20	245	124	35	154	410
95	16	1520	240	0	10	40	90	520	240	40	231	158	21	196	400
95	17	1060	240	65	110	70	110	330	430	50	105	160	0	168	280
95	18	3240	520	20	95	110	110	410	770	100	525	246	35	273	420
95	19	1620	340	70	10	380	310	790	390	30	364	220	112	189	460
95	20	4160	140	40	60	150	180	540	270	40	280	178	21	63	680
95	21	1060	120	20	0	200	240	410	360	60	175	24	28	189	60
95	22	160	400	84	100	50	110	400	320	150	532	0	7	641	100
95	23	2320	180	25	10	170	200	540	200	30	196	0	14	217	1040
95	24	1480	200	90	90	140	80	400	50	60	77	34	49	77	430
95	25	3980	80	30	60	210	110	480	110	40	112	10	35	91	70
95	26	3040	200	0	30	150	110	700	290	150	252	0	91	147	560
95	27	740	80	55	55	0	30	200	100	20	98	0	0	42	200
95	28	1220	120	20	125	220	350	770	170	70	231	10	56	77	610
95	29	1540	200	30	55	20	100	490	150	60	203	8	7	14	200
95	30	1860	520	80	0	160	170	272	135	130	238	10	56	42	550
95	31	1300	250	25	125	280	330	500	520	40	112	8	84	126	550
95	32	3760	200	35	20	150	160	430	560	100	63	28	49	119	460
95	33	1580	260	15	60	10	40	480	220	90	84	32	14	245	350
95	34	2740	260	15	115	40	90	310	370	40	203	14	42	189	180
95	35	1280	520	90	55	110	150	420	310	40	49	0	21	35	460
95	36	2440	580	50	110	80	120	330	480	30	259	24	49	196	0
95	37	1380	240	35	5	50	110	200	140	30	210	6	35	238	450
95	38	2620	220	0	55	140	200	520	510	150	329	54	14	70	470
95	39	1340	680	50	60	70	140	540	630	20	63	32	42	98	80
95	40	2500	140	0	0	60	50	520	670	110	140	44	42	56	580
95	41	1200	500	35	90	90	90	230	440	70	210	34	56	98	540

95	42	2980	140	80	25	90	210	580	300	90	189	82	14	35	400
95	43	3160	620	20	130	100	210	260	630	130	210	92	49	658	150
95	44	4600	290	65	0	50	100	480	920	50	231	52	21	154	0
95	45	1700	200	25	10	170	80	300	400	180	385	82	35	392	600
95	46	2840	180	10	10	110	180	620	740	90	315	2	91	385	800
95	47	780	280	10	0	120	160	200	140	140	350	130	35	252	80
95	48	2960	480	30	60	20	200	190	290	250	602	130	35	189	520
95	49	660	0	95	5	80	90	220	420	10	70	16	7	112	410
95	50	360	20	80	155	110	120	230	200	70	140	56	28	105	420
95	51	2360	740	5	55	250	170	980	430	50	203	36	28	42	450
96	1	400	260	0	0	60	90	800	270	30	42	16	7	35	400
96	2	940	140	0	10	20	0	220	30	60	245	26	42	175	0
96	3	3600	60	25	5	160	160	870	170	20	56	24	77	112	520
96	4	2700	860	30	110	90	320	420	320	70	98	40	70	56	400
96	5	1620	480	20	35	200	130	1020	290	60	301	12	14	161	490
96	6	2340	120	135	5	140	130	330	420	80	84	16	56	105	650
96	7	820	240	75	85	120	90	140	200	40	126	40	84	49	0
96	8	540	220	55	60	120	200	380	220	90	63	30	14	63	480
96	9	3020	380	0	40	60	70	160	500	30	147	62	7	133	0
96	10	3460	440	30	175	180	220	340	430	160	175	42	35	105	590
96	11	2480	260	15	10	140	110	300	130	10	119	56	28	203	400
96	12	3340	600	40	75	50	70	240	330	60	91	10	49	168	410
96	13	2940	220	50	5	220	150	310	460	150	252	48	63	147	480
96	14	2580	300	0	15	130	90	420	430	60	105	44	7	77	550
96	15	2540	560	10	0	150	170	270	140	80	245	118	119	126	60
96	16	1620	0	60	0	130	330	600	170	80	63	96	49	210	450
96	17	2760	920	30	20	220	190	290	320	160	245	124	7	245	0
96	18	900	60	50	0	140	60	270	100	120	147	46	133	203	500
96	19	2600	140	10	5	290	120	400	280	20	70	12	7	196	980
96	20	1320	160	0	5	150	130	270	260	80	147	122	84	182	480
96	21	3640	860	65	20	120	350	170	190	60	133	30	49	182	490
96	22	2380	320	10	10	300	210	510	200	180	119	26	14	154	400
96	23	600	60	15	0	160	220	250	160	80	196	70	21	175	10
96	24	3520	780	45	80	450	180	530	220	80	224	108	42	238	720
96	25	1460	300	0	0	310	200	180	420	60	63	64	42	238	420
96	26	1060	540	20	5	280	50	540	240	230	315	108	42	371	520
96	27	3280	40	0	0	70	100	150	203	20	28	8	0	35	50
96	28	1480	240	105	15	180	50	310	380	20	126	88	42	182	980
96	29	1700	60	100	15	130	120	830	220	80	175	96	119	231	0
96	30	1840	360	30	20	260	180	370	550	80	168	156	35	273	420
96	31	1140	280	105	0	130	140	440	230	100	210	56	21	497	70
96	32	2640	980	35	0	360	150	620	310	120	161	52	28	154	900
96	33	680	260	10	0	130	220	350	400	60	224	74	7	287	0
96	34	2200	440	80	25	180	170	520	250	100	196	92	70	287	170
96	35	1720	360	0	10	210	140	270	381	170	84	34	0	175	840
96	36	1300	40	0	10	160	150	380	170	170	280	44	49	224	700
96	37	1400	780	80	0	460	280	510	510	70	147	34	35	266	450
96	38	820	660	35	0	200	130	410	110	100	252	132	21	259	400
96	39	1720	290	80	0	130	360	410	360	50	217	22	70	189	120
96	40	2260	290	15	10	20	160	130	230	80	63	30	21	119	400

Outlier Adjusted Data - B Items

Attachment 4

Yr	Wk	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B12
	Mean	72.20	15.17	64.73	2.69	84.60	59.55	24.42	149.50	15.74	61.97	9.94
	Standard Dev	61.55	17.31	65.42	5.43	80.70	52.73	31.79	96.56	32.89	97.98	23.00
	f	0.93	0.69	0.84	0.30	0.88	0.86	0.67	0.97	0.24	0.38	0.27
	Std Package	10	5	10	1	10	10	10	2	40	20	5
93	22	50	5	20	0	80	60	0	164	0	0	60
93	23	170	35	150	4	90	90	110	270	0	80	70
93	24	120	0	80	4	0	100	140	498	0	0	20
93	25	70	55	140	4	120	100	30	84	0	40	25
93	26	180	35	80	0	310	0	20	0	80	0	40
93	27	40	50	10	0	100	10	0	0	0	160	25
93	28	80	25	80	0	120	180	20	202	0	0	0
93	29	130	40	130	0	10	80	20	334	0	360	0
93	30	80	10	238	4	50	150	30	198	0	0	25
93	31	20	25	80	0	0	10	30	242	0	0	0
93	32	50	65	30	0	8	60	0	72	80	200	0
93	33	30	5	0	0	0	0	0	524	0	0	0
93	34	170	35	0	8	0	0	10	112	0	0	0
93	35	20	10	0	0	0	0	0	220	0	0	0
93	36	0	20	0	0	0	13	0	302	0	80	0
93	37	8	10	0	0	0	0	80	100	0	0	0
93	38	0	0	0	0	19	60	0	64	0	0	0
93	39	0	40	0	0	0	100	30	110	0	80	0
93	40	80	15	0	0	0	60	0	130	0	0	0
93	41	40	35	0	0	0	10	50	114	0	0	0
93	42	130	20	80	12	460	40	30	138	0	0	0
93	43	30	50	150	0	100	0	50	250	0	320	0
93	44	40	25	40	0	190	20	0	104	0	0	0
93	45	90	5	110	20	120	30	20	238	0	0	0
93	46	80	20	160	0	110	20	0	122	40	0	0
93	47	30	30	20	0	100	10	0	86	0	0	0
93	48	90	15	90	0	30	70	0	290	0	0	0
93	49	190	20	50	0	70	10	10	166	0	160	0
93	50	80	0	10	0	90	50	30	212	0	80	0
93	51	100	50	260	20	170	0	90	196	0	360	0
94	1	210	15	80	0	60	40	10	256	0	0	0
94	2	190	10	130	0	230	60	30	220	0	360	0
94	3	20	25	50	25	70	50	0	194	0	200	0
94	4	80	20	40	0	60	40	0	110	0	0	0
94	5	120	30	100	0	180	230	50	334	0	160	20
94	6	50	0	30	0	120	20	10	82	0	0	0
94	7	80	20	80	0	40	130	140	260	80	80	0
94	8	40	0	50	0	70	0	30	184	80	0	0
94	9	20	0	80	0	240	60	10	282	0	320	20
94	10	60	45	160	0	80	50	50	458	0	0	0
94	11	90	10	100	8	100	90	30	206	0	0	30
94	12	240	10	50	0	60	80	20	164	0	0	0
94	13	40	20	40	0	60	60	40	164	0	0	20
94	14	190	100	140	0	90	0	10	90	0	240	0
94	15	80	10	10	0	30	60	20	160	40	0	20
94	16	40	0	40	8	70	20	10	92	0	0	0
94	17	80	20	100	0	190	20	100	156	0	0	20
94	18	20	10	180	24	130	70	0	120	0	160	0
94	19	160	0	120	0	60	0	20	158	0	120	0
94	20	140	10	10	0	0	70	0	194	80	160	10
94	21	50	15	160	0	80	70	40	144	0	40	0
94	22	190	0	30	0	20	0	0	94	0	200	0
94	23	200	40	100	0	30	70	10	146	0	80	0
94	24	50	0	50	0	90	10	0	262	0	319	0
94	25	80	35	220	0	84	70	40	202	0	0	0

94	26	0	25	20	0	300	80	10	178	160	160	0
94	27	30	0	30	0	0	40	0	44	0	0	100
94	28	20	35	350	0	110	30	140	114	0	120	0
94	29	110	20	80	0	40	30	0	106	40	0	10
94	30	240	5	140	0	180	60	10	200	0	160	20
94	31	160	20	110	0	50	40	0	200	40	120	0
94	32	90	10	100	0	220	70	0	194	80	0	20
94	33	70	80	150	0	70	20	20	262	0	0	10
94	34	130	20	60	0	0	100	0	130	40	200	0
94	35	80	15	250	0	60	50	10	278	80	160	0
94	36	10	0	80	0	20	10	10	102	0	0	30
94	37	50	5	160	0	30	90	90	164	0	240	20
94	38	130	60	120	0	30	40	0	144	0	0	0
94	39	20	0	100	8	290	30	50	246	0	0	0
94	40	70	10	50	0	60	110	70	96	0	0	5
94	41	20	0	120	0	70	20	0	104	0	120	0
94	42	170	35	110	0	10	40	60	124	40	320	5
94	43	80	35	10	0	50	60	30	280	0	160	120
94	44	130	5	70	0	20	30	40	274	80	0	0
94	45	190	20	60	0	0	0	110	316	40	0	0
94	46	80	10	40	16	50	90	10	216	0	320	0
94	47	0	5	20	0	100	90	0	176	0	0	0
94	48	10	25	20	4	100	20	30	252	0	0	0
94	49	120	5	10	8	0	30	10	502	40	0	0
94	50	60	60	80	0	60	20	10	164	0	120	0
94	51	40	25	30	0	140	0	0	164	0	0	0
95	1	90	20	70	0	340	30	20	104	40	0	20
95	2	100	10	120	0	120	50	90	98	0	0	0
95	3	50	25	0	0	30	110	20	122	0	0	0
95	4	80	5	20	0	120	20	0	118	108	0	0
95	5	20	40	110	0	90	40	0	126	0	0	0
95	6	200	25	230	0	230	70	30	92	0	0	15
95	7	40	50	30	10	140	40	20	204	0	0	0
95	8	10	25	0	24	20	0	0	130	0	0	20
95	9	290	25	280	24	110	30	100	182	120	0	90
95	10	20	30	20	4	80	70	0	222	0	160	0
95	11	160	25	40	0	70	20	10	178	80	0	0
95	12	40	25	240	0	140	80	10	142	0	40	0
95	13	40	10	60	0	170	10	10	242	160	0	20
95	14	50	10	0	20	30	50	40	218	0	80	25
95	15	60	20	170	8	60	80	70	114	0	0	0
95	16	70	0	80	8	100	0	10	230	0	0	0
95	17	80	5	20	0	80	0	20	220	40	200	0
95	18	10	5	40	0	50	80	20	282	0	0	0
95	19	40	50	80	0	140	60	10	164	40	0	0
95	20	240	35	110	8	150	0	80	252	0	160	100
95	21	20	0	60	0	20	30	20	212	0	160	0
95	22	110	0	40	0	140	50	40	160	0	0	0
95	23	80	30	20	4	310	0	0	34	0	40	0
95	24	80	20	0	0	10	70	40	24	0	40	0
95	25	20	0	200	8	60	20	40	24	40	0	0
95	26	40	20	40	0	170	130	10	36	0	160	50
95	27	20	5	0	0	0	0	0	0	40	0	0
95	28	30	0	50	0	50	50	0	68	40	0	0
95	29	50	0	60	4	20	70	0	0	80	400	0
95	30	300	15	10	0	10	10	60	0	0	0	0
95	31	0	0	60	0	70	60	0	2	0	0	0
95	32	40	5	50	8	30	60	60	46	0	0	0
95	33	40	0	20	0	50	20	20	54	40	0	0
95	34	50	0	0	0	20	20	10	0	0	0	0
95	35	20	0	50	18	10	30	0	88	0	0	0

95	36	40	20	30	4	70	70	70	110	0	240	10
95	37	20	40	120	4	0	140	0	76	0	0	0
95	38	10	0	0	0	110	20	70	76	0	160	10
95	39	130	20	80	0	160	50	10	60	0	0	0
95	40	150	0	10	0	110	60	10	90	40	0	0
95	41	0	0	0	0	120	20	10	56	40	120	5
95	42	70	0	0	4	100	10	50	94	0	0	0
95	43	120	5	130	4	100	70	20	208	0	160	40
95	44	160	0	50	0	30	50	10	34	40	0	0
95	45	50	15	0	0	90	90	50	66	0	80	30
95	46	40	5	0	0	60	20	20	6	0	80	20
95	47	120	10	100	0	0	50	0	36	80	0	0
95	48	50	5	190	4	170	20	10	390	0	0	0
95	49	10	0	30	0	110	0	20	32	0	0	0
95	50	30	30	0	12	50	0	0	66	0	0	0
95	51	80	0	160	0	210	0	10	54	0	0	0
96	1	50	0	60	4	30	90	140	32	0	0	0
96	2	30	20	20	8	10	0	0	64	0	0	0
96	3	30	20	20	12	0	130	20	30	0	120	0
96	4	0	5	20	12	10	50	10	30	40	0	0
96	5	100	0	10	4	80	130	30	42	0	0	15
96	6	60	25	50	12	80	190	0	28	0	0	50
96	7	0	0	0	0	50	60	20	66	0	0	0
96	8	30	0	80	0	90	200	0	48	0	120	0
96	9	60	10	10	0	100	150	0	80	0	0	50
96	10	90	0	10	0	20	150	40	80	0	120	0
96	11	70	0	20	4	170	100	10	112	0	0	0
96	12	50	0	30	0	50	90	0	54	0	120	0
96	13	20	5	30	0	70	230	10	134	80	40	0
96	14	10	0	110	3	40	50	10	162	40	0	0
96	15	20	20	30	0	40	10	100	74	0	40	0
96	16	30	0	10	1	440	170	20	136	0	80	35
96	17	10	5	30	4	50	60	10	168	0	80	0
96	18	100	0	40	0	90	140	0	94	0	40	0
96	19	80	20	10	4	0	80	0	172	0	0	0
96	20	50	0	20	4	200	70	20	226	80	0	0
96	21	50	10	0	0	70	40	10	150	0	160	5
96	22	100	10	0	0	30	60	0	158	0	0	0
96	23	10	0	60	0	110	180	0	134	0	0	100
96	24	40	0	50	0	50	190	20	186	0	0	0
96	25	60	5	20	0	50	10	20	90	0	160	105
96	26	80	0	70	4	50	110	40	240	80	0	0
96	27	120	0	10	0	50	0	0	60	0	0	0
96	28	20	5	10	0	140	150	100	124	0	0	0
96	29	0	0	0	5	70	50	0	92	0	0	0
96	30	30	0	20	0	120	100	0	144	0	0	0
96	31	190	0	50	0	60	110	10	258	0	0	0
96	32	80	5	20	0	20	120	30	150	40	300	0
96	33	50	5	50	5	100	140	0	112	0	120	0
96	34	70	5	40	0	0	120	0	176	0	320	0
96	35	30	10	66	4	120	200	20	134	0	0	55
96	36	20	0	0	0	60	70	20	138	160	0	0
96	37	40	0	130	0	110	160	20	194	0	0	95
96	38	0	0	40	0	40	200	0	172	40	0	0
96	39	40	0	80	15	280	40	70	142	0	0	0
96	40	0	15	0	0	20	10	0	82	0	0	0

Half-Week Demands - A Items

	A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	A12	A13	A14
Sample Mean	762.11	118.40	32.56	28.64	47.89	52.86	200.42	174.21	71.41	126.35	70.93	18.43	78.29	182.60
Sample S.D.	758.27	135.57	46.18	36.68	60.30	49.58	150.59	158.96	74.02	111.29	75.18	26.75	78.91	233.51
Ex Post Mean	1009.41	174.61	18.82	13.92	80.39	78.43	198.24	157.98	44.12	89.28	29.61	20.38	95.19	198.73
Ex Post S.D.	863.83	214.97	27.81	31.13	83.81	66.94	160.31	134.97	41.01	79.11	32.06	22.51	97.33	256.41
Overall Mean	835.44	135.07	28.49	24.27	57.53	60.44	199.77	169.40	63.32	115.36	58.68	19.01	83.30	187.38
Overall S.D.	797.82	164.87	42.02	35.72	69.60	56.42	153.30	152.23	67.09	104.08	68.06	25.55	84.99	240.26
Half-Week #														
0.5	0	0	40	0	70	20	100	10	50	196	170	7	98	0
1.0	900	160	0	0	0	20	130	20	100	21	0	0	28	0
1.5	2210	10	5	0	0	10	230	60	70	237	298	7	182	220
2.0	190	150	55	55	0	20	110	20	120	316	88	63	98	0
2.5	230	20	20	70	0	40	10	110	40	3	342	126	84	50
3.0	110	160	40	0	40	50	510	30	100	221	8	7	84	400
3.5	730	490	60	60	10	80	190	120	60	26	0	0	77	0
4.0	1190	50	75	0	10	80	110	30	60	221	130	0	266	390
4.5	630	0	0	0	10	70	280	160	40	44	18	0	28	90
5.0	250	60	195	50	10	30	100	60	0	5	220	0	84	460
5.5	660	0	0	0	0	10	150	40	240	11	4	0	0	40
6.0	460	0	155	0	0	110	160	40	50	3	92	0	0	0
6.5	1050	200	45	55	130	20	20	20	240	140	200	0	7	0
7.0	250	120	70	0	0	30	290	50	40	107	138	42	0	0
7.5	540	260	60	35	0	0	360	120	140	188	62	140	77	0
8.0	740	0	0	15	20	190	290	50	90	344	114	0	210	0
8.5	970	0	0	0	0	0	70	100	110	48	106	0	56	40
9.0	370	380	230	60	40	80	80	0	40	22	32	63	14	0
9.5	2180	0	40	0	0	40	100	20	40	177	122	0	91	300
10.0	280	200	0	0	40	20	0	120	60	68	112	0	21	300
10.5	260	80	235	45	10	20	140	30	260	41	34	0	0	150
11.0	880	160	0	0	0	0	100	100	190	113	46	0	0	20
11.5	120	0	0	0	30	10	150	20	30	560	0	0	91	0
12.0	140	140	100	55	270	0	80	20	60	49	190	0	112	0
12.5	170	0	160	0	40	40	70	40	0	268	62	63	42	40
13.0	1370	180	0	75	10	20	250	220	150	54	250	56	280	380
13.5	450	110	0	35	40	30	50	170	10	237	0	0	35	60
14.0	380	150	235	0	0	0	150	40	50	183	300	0	21	290
14.5	140	170	5	0	60	40	400	100	0	85	28	0	0	10
15.0	340	180	55	65	0	20	30	0	250	118	82	0	483	10
15.5	300	20	60	0	0	40	110	70	40	36	80	105	84	0
16.0	0	214	100	0	30	30	90	130	210	405	128	0	105	250
16.5	160	20	10	0	50	30	160	40	20	142	0	0	14	310
17.0	20	0	225	55	0	0	270	100	90	124	148	7	35	0
17.5	240	0	40	80	10	50	340	60	300	93	132	0	77	40
18.0	460	0	0	0	90	20	40	120	110	362	188	63	28	510
18.5	1000	0	20	30	50	70	310	230	30	19	90	7	63	110
19.0	0	0	10	0	10	30	240	90	50	205	4	0	7	190
19.5	1630	180	60	10	10	0	10	270	160	120	240	7	21	260
20.0	250	0	55	45	0	70	290	30	40	76	0	0	7	150
20.5	40	210	0	0	0	90	420	80	0	140	106	0	63	20
21.0	900	150	0	100	120	0	30	60	130	140	98	21	42	60
21.5	2130	80	0	100	120	0	110	210	110	331	138	14	14	400
22.0	530	200	90	0	0	80	150	130	90	215	96	0	28	0
22.5	710	70	10	50	10	0	100	120	150	291	116	35	42	0
23.0	790	190	110	0	0	40	0	10	30	38	0	42	63	10
23.5	450	0	10	0	30	80	40	90	140	36	0	7	77	0
24.0	730	480	10	90	60	50	280	190	80	279	212	0	0	620
24.5	540	170	85	0	10	30	220	150	140	228	28	0	63	10
25.0	360	70	45	15	30	60	220	110	20	3	288	7	35	50
25.5	0	20	220	200	10	60	40	180	10	54	32	21	7	480
26.0	0	40	0	0	120	110	150	40	0	170	18	91	56	0
26.5	310	0	0	0	50	0	240	140	140	195	208	42	147	0
27.0	1050	240	25	50	30	90	20	40	80	141	66	7	70	30
27.5	420	20	0	0	0	100	250	100	0	117	82	56	14	650

28.0	0	160	140	15	20	0	280	190	142	324	116	35	133	0
28.5	260	120	45	85	10	100	150	100	40	173	0	0	259	0
29.0	840	60	0	0	0	0	160	160	50	30	174	56	21	100
29.5	170	440	0	25	90	40	40	40	80	229	272	0	182	0
30.0	810	0	30	30	10	80	160	390	70	401	102	119	77	460
30.5	920	0	20	60	50	0	210	10	80	85	72	0	140	0
31.0	0	0	5	0	10	30	90	150	150	265	100	0	77	560
31.5	2490	10	5	55	80	0	260	60	250	111	0	49	182	0
32.0	1330	10	60	0	30	40	250	830	0	50	156	63	7	230
32.5	470	0	5	0	0	0	50	20	100	107	82	35	21	50
33.0	230	0	5	55	0	10	330	180	0	47	110	0	56	0
33.5	670	10	60	45	170	10	280	160	130	300	74	0	70	0
34.0	50	190	60	20	10	240	110	230	20	183	86	70	119	650
34.5	360	280	75	0	0	10	470	40	140	280	298	14	343	350
35.0	980	100	0	10	10	20	50	460	70	28	0	21	7	100
35.5	0	90	100	0	20	30	10	0	20	15	40	21	140	0
36.0	380	10	15	75	40	20	160	230	0	34	70	0	14	0
36.5	20	160	0	60	0	110	230	430	60	138	4	7	28	340
37.0	3240	40	65	0	340	30	290	240	50	65	146	0	105	70
37.5	1120	0	5	130	20	10	60	320	30	164	36	7	98	50
38.0	0	280	5	0	0	20	60	30	0	32	126	14	35	0
38.5	890	10	0	0	130	30	80	0	110	170	210	49	0	530
39.0	150	250	60	0	0	30	170	160	90	152	18	7	315	100
39.5	630	460	10	35	0	40	340	340	110	75	316	105	189	400
40.0	470	0	75	0	90	60	190	80	90	590	40	21	0	0
40.5	270	0	85	60	10	20	380	230	30	316	126	0	140	0
41.0	490	100	65	0	30	100	140	160	130	265	280	70	105	0
41.5	190	0	25	5	20	0	230	420	70	262	112	14	21	0
42.0	30	60	0	45	50	10	360	530	0	200	0	28	448	0
42.5	10	540	110	100	90	30	20	30	20	76	66	35	0	1000
43.0	870	40	50	0	60	40	260	340	160	171	64	14	189	270
43.5	2980	0	50	55	0	10	170	190	210	8	62	0	91	50
44.0	200	0	5	10	80	10	190	0	50	62	0	0	84	0
44.5	640	200	0	0	0	40	40	60	150	312	140	35	42	10
45.0	660	80	20	60	50	40	390	570	80	17	62	0	35	0
45.5	1790	0	40	10	90	0	10	40	0	118	74	0	119	720
46.0	30	0	0	110	20	60	280	280	60	22	42	84	182	840
46.5	160	390	0	50	0	10	70	60	40	75	102	7	105	0
47.0	540	270	140	20	30	60	310	70	360	149	24	21	0	480
47.5	140	260	55	135	50	20	60	80	10	76	0	0	35	100
48.0	420	0	30	35	0	20	300	140	20	8	98	7	119	0
48.5	680	80	10	0	90	140	280	430	50	144	62	21	140	810
49.0	680	40	20	5	30	50	340	40	100	73	54	0	0	370
49.5	0	130	0	0	0	60	110	20	120	353	112	7	70	480
50.0	600	70	10	60	40	50	210	170	80	53	0	0	105	0
50.5	890	0	100	10	100	60	160	30	180	30	98	14	28	0
51.0	1730	0	30	45	0	0	320	290	40	222	54	21	77	620
51.5	680	0	20	60	0	20	380	220	40	35	26	21	28	480
52.0	220	0	80	0	0	20	130	10	20	49	34	0	70	0
52.5	320	140	65	20	50	0	20	250	70	61	0	0	112	0
53.0	540	0	0	30	40	100	600	40	30	93	198	0	21	690
53.5	720	90	20	0	110	80	380	350	160	62	0	7	14	0
54.0	240	10	0	0	60	60	10	200	10	351	146	0	105	480
54.5	0	10	0	35	10	90	210	330	100	41	0	0	49	30
55.0	1400	290	21	20	30	10	494	30	230	253	288	0	63	20
55.5	0	80	50	75	0	90	190	190	130	121	24	14	0	330
56.0	620	20	0	0	80	0	90	650	70	187	176	14	133	10
56.5	260	160	0	0	0	0	300	190	0	18	44	21	14	310
57.0	2800	0	10	0	0	0	70	390	0	73	0	0	0	290
57.5	370	250	35	0	20	20	310	240	110	29	14	14	0	710
58.0	730	170	0	35	30	30	90	50	30	118	60	0	147	200
58.5	400	20	15	55	80	10	10	80	120	238	30	14	14	40
59.0	60	20	0	95	0	60	210	140	70	0	142	0	147	60

59.5	660	0	0	85	10	10	540	570	160	101	36	21	63	550
60.0	400	240	15	15	50	80	60	80	0	32	86	0	56	0
60.5	1810	120	0	0	60	30	220	0	60	72	116	70	91	150
61.0	250	100	0	5	0	30	70	270	40	138	10	14	42	30
61.5	1620	0	145	0	80	50	20	220	150	38	0	21	42	0
62.0	40	200	0	75	90	20	410	130	30	130	84	7	91	360
62.5	350	0	75	0	0	0	70	90	20	311	84	49	56	0
63.0	270	20	0	65	50	20	60	150	210	11	122	0	70	450
63.5	40	0	0	10	0	140	80	190	160	513	46	7	84	540
64.0	880	320	80	15	140	0	340	190	0	47	50	0	126	70
64.5	930	140	0	0	60	50	170	400	140	176	80	0	266	0
65.0	210	0	110	95	20	30	300	60	10	48	34	0	0	60
65.5	880	20	0	5	10	100	240	50	50	92	40	0	21	300
66.0	360	0	0	0	10	0	40	220	150	13	12	28	238	0
66.5	1940	150	10	5	30	20	200	380	80	224	100	7	161	200
67.0	1080	130	10	165	110	70	500	80	70	84	80	7	112	210
67.5	160	100	0	0	0	50	30	80	110	130	64	21	42	0
68.0	360	0	30	110	100	20	190	320	40	59	18	7	49	940
68.5	430	260	25	5	10	10	170	90	180	230	0	56	77	0
69.0	630	0	25	95	50	0	160	360	10	15	160	56	119	30
69.5	770	140	20	0	0	120	260	20	50	102	70	42	168	400
70.0	1590	0	15	0	130	0	0	200	20	17	20	0	0	0
70.5	1100	10	0	0	200	50	70	120	100	61	112	14	56	0
71.0	320	30	100	145	0	10	460	440	10	163	12	7	14	50
71.5	980	140	0	20	130	10	300	540	120	122	56	49	70	0
72.0	1960	300	10	0	0	140	80	90	60	109	108	14	147	260
72.5	1380	0	45	0	110	230	100	200	120	116	68	14	84	290
73.0	40	340	70	80	90	10	240	330	40	129	38	14	182	110
73.5	20	0	50	60	0	70	140	60	10	17	102	7	112	120
74.0	2540	280	10	0	0	110	450	450	30	95	32	0	0	310
74.5	330	640	0	0	40	90	330	410	210	266	0	0	105	0
75.0	410	0	50	55	150	90	90	100	100	105	128	0	133	120
75.5	700	210	10	30	120	40	150	170	90	146	66	0	7	70
76.0	340	150	0	30	60	20	400	370	50	15	78	14	91	470
76.5	2840	340	10	0	150	50	50	140	120	159	102	0	0	0
77.0	0	20	0	20	50	30	70	80	30	9	46	49	119	500
77.5	1040	320	35	5	0	140	480	370	100	192	118	0	42	500
78.0	100	60	10	55	183	43	285	10	80	55	60	14	147	0
78.5	830	160	60	60	10	60	450	270	460	81	258	28	196	0
79.0	410	240	0	0	0	70	10	130	150	220	74	14	0	0
79.5	560	180	0	20	0	120	130	440	60	314	82	7	35	70
80.0	720	100	0	0	190	100	120	370	30	78	38	0	112	0
80.5	1560	600	60	0	10	170	400	100	0	329	66	77	56	470
81.0	520	0	110	50	140	60	290	565	330	378	64	63	133	10
81.5	310	0	0	0	70	40	70	90	30	64	88	0	14	600
82.0	1510	160	80	10	60	100	80	320	10	76	0	42	56	10
82.5	380	40	25	0	30	60	110	250	110	75	0	28	112	0
83.0	1300	0	35	0	80	140	260	110	20	44	32	0	0	500
83.5	1180	540	0	5	0	0	410	140	10	56	0	35	7	0
84.0	900	0	0	5	50	100	80	410	30	112	70	0	28	0
84.5	1130	480	10	0	0	70	140	70	50	12	4	21	42	0
85.0	2050	0	25	35	120	20	260	750	90	177	22	0	14	130
85.5	60	200	20	45	0	90	0	150	430	261	42	0	35	440
86.0	500	40	5	25	60	70	840	310	40	33	64	0	84	60
86.5	330	0	0	0	30	0	240	220	40	11	110	7	21	0
87.0	1290	40	10	110	0	180	300	110	0	59	0	0	119	320
87.5	240	160	25	20	10	0	350	620	50	126	44	0	42	0
88.0	740	60	45	0	10	10	90	20	10	161	128	7	77	460
88.5	460	180	10	0	87	20	40	10	20	3	34	21	147	0
89.0	1080	80	0	60	0	40	150	430	70	116	28	0	14	190
89.5	350	180	145	0	30	40	40	150	40	166	24	14	42	90
90.0	3090	20	0	5	90	120	360	370	100	79	136	21	14	870
90.5	290	180	45	35	170	50	60	260	70	35	36	28	182	360

91.0	490	120	0	45	0	60	190	190	150	217	150	28	0	10
91.5	3480	10	50	30	10	20	180	90	40	145	102	0	224	60
92.0	160	90	0	0	110	80	300	300	10	44	20	119	7	0
92.5	30	0	0	85	100	80	440	420	0	113	0	7	126	0
93.0	1710	140	70	5	10	60	100	70	10	76	110	0	0	1010
93.5	390	420	10	0	260	210	180	70	20	145	38	0	105	30
94.0	3870	0	15	90	0	90	160	330	70	23	124	14	112	60
94.5	330	100	50	5	180	60	170	20	70	175	32	14	77	210
95.0	410	0	0	25	0	60	340	50	60	0	76	14	77	300
95.5	530	0	0	0	160	0	170	320	20	9	30	35	147	410
96.0	490	420	0	55	0	60	220	110	0	236	94	0	7	0
96.5	820	170	0	0	40	70	500	150	40	54	158	14	49	220
97.0	700	70	0	10	0	20	20	90	0	177	0	7	147	180
97.5	160	40	15	70	50	10	270	280	50	67	160	0	168	0
98.0	900	200	50	40	20	100	60	150	0	38	0	0	0	280
98.5	1880	430	0	90	70	60	330	730	0	52	22	35	273	0
99.0	1360	90	20	5	40	50	80	40	100	473	224	0	0	420
99.5	1200	230	70	10	380	140	640	0	10	348	220	112	28	320
100.0	420	110	0	0	0	170	150	390	20	16	0	0	161	140
100.5	270	70	40	50	30	180	490	210	20	155	0	7	56	660
101.0	3890	70	0	10	120	0	50	60	20	125	178	14	7	20
101.5	0	110	5	0	150	60	140	280	20	74	24	0	168	60
102.0	1060	10	15	0	50	180	270	80	40	101	0	28	21	0
102.5	10	0	15	95	10	30	270	110	0	59	0	7	266	80
103.0	150	400	69	5	40	80	130	210	150	473	0	0	375	20
103.5	1960	10	10	0	50	120	120	50	20	99	0	7	126	930
104.0	360	170	15	10	120	80	420	150	10	97	0	7	91	110
104.5	50	200	90	0	110	10	70	40	0	57	34	0	0	180
105.0	1430	0	0	90	30	70	330	10	60	20	0	49	77	250
105.5	3360	20	0	30	100	50	210	20	40	106	0	21	0	20
106.0	620	60	30	30	110	60	270	90	0	6	10	14	91	50
106.5	1500	30	0	30	130	0	220	200	130	160	0	0	105	340
107.0	1540	170	0	0	20	110	480	90	20	92	0	91	42	220
107.5	360	30	25	15	0	10	110	20	0	20	0	0	7	0
108.0	380	50	30	40	0	20	90	80	20	78	0	0	35	200
108.5	70	80	20	0	120	160	20	30	50	156	4	49	7	580
109.0	1150	40	0	125	100	190	750	140	20	75	6	7	70	30
109.5	1350	180	20	55	20	100	270	150	10	29	8	7	0	90
110.0	190	20	10	0	0	0	220	0	50	174	0	0	14	110
110.5	790	200	75	0	150	110	170	20	50	213	4	0	42	550
111.0	1070	320	5	0	10	60	102	115	80	25	6	56	0	0
111.5	0	140	25	125	230	240	30	300	30	69	6	21	0	0
112.0	1300	110	0	0	50	90	470	220	10	43	2	63	126	550
112.5	1900	70	15	20	50	80	170	10	80	55	0	28	0	0
113.0	1860	130	20	0	100	80	260	550	20	8	28	21	119	460
113.5	1480	260	15	5	0	20	130	200	50	20	0	0	147	0
114.0	100	0	0	55	10	20	350	20	40	64	32	14	98	350
114.5	1010	230	5	35	0	90	310	260	10	102	0	42	154	0
115.0	1730	30	10	80	40	0	0	110	30	101	14	0	35	180
115.5	390	290	35	40	60	30	50	20	40	12	0	21	28	380
116.0	890	230	55	15	50	120	370	290	0	37	0	0	7	80
116.5	1140	540	50	65	0	90	290	330	30	150	0	49	140	0
117.0	1300	40	0	45	80	30	40	150	0	109	24	0	56	0
117.5	730	240	0	5	50	110	10	80	20	25	6	28	182	450
118.0	650	0	35	0	0	0	190	60	10	185	0	7	56	0
118.5	1280	220	0	55	20	120	120	230	150	326	54	7	35	470
119.0	1340	0	0	0	120	80	400	280	0	3	0	7	35	0
119.5	0	220	0	25	0	50	40	360	0	7	26	0	14	0
120.0	1340	460	50	35	70	90	500	270	20	56	6	42	84	80
120.5	20	0	0	0	30	10	10	600	40	64	30	7	21	280
121.0	2480	140	0	0	30	40	510	70	70	76	14	35	35	300
0.5	190	0	20	0	20	30	60	420	60	92	10	56	70	220
1.0	1010	500	15	90	70	60	170	20	10	118	24	0	28	320

1.5	1520	140	35	0	90	210	170	240	90	23	0	7	7	0
2.0	1460	0	45	25	0	0	410	60	0	166	82	7	28	400
2.5	1960	0	15	100	10	180	30	410	50	204	92	7	105	110
3.0	1200	620	5	30	90	30	230	220	80	6	0	42	553	40
3.5	3980	280	65	0	20	80	40	900	20	157	46	0	119	0
4.0	620	10	0	0	30	20	440	20	30	74	6	21	35	0
4.5	1160	70	15	10	30	10	90	260	110	80	0	0	98	340
5.0	540	130	10	0	140	70	210	140	70	305	82	35	294	260
5.5	2410	180	10	10	80	140	220	250	60	295	0	7	245	800
6.0	430	0	0	0	30	40	400	490	30	20	2	84	140	0
6.5	120	80	10	0	100	130	100	40	140	82	114	14	210	0
7.0	660	200	0	0	20	30	100	100	0	268	16	21	42	80
7.5	2920	480	0	40	20	130	180	240	90	363	104	35	168	110
8.0	40	0	30	20	0	70	10	50	160	239	26	0	21	410
8.5	0	0	95	5	20	30	30	70	10	26	16	7	14	320
9.0	660	0	0	0	60	60	190	350	0	44	0	0	98	90
9.5	110	10	20	155	10	60	70	190	20	115	26	14	105	0
10.0	250	10	60	0	100	60	160	10	50	25	30	14	0	420
10.5	2180	520	5	50	170	90	540	240	10	199	0	0	42	450
11.0	180	220	0	5	80	80	440	190	40	4	36	28	0	0
11.5	400	60	0	0	40	10	680	220	0	0	16	0	7	0
12.0	0	200	0	0	20	80	120	50	30	42	0	7	28	400
12.5	870	60	0	10	0	0	120	20	10	145	4	42	168	0
13.0	70	80	0	0	20	0	100	10	50	100	22	0	7	0
13.5	2220	60	25	5	110	60	720	30	20	34	22	63	21	250
14.0	1380	0	0	0	50	100	150	140	0	22	2	14	91	270
14.5	440	50	30	105	90	230	280	290	40	21	8	42	14	400
15.0	2260	810	0	5	0	90	140	30	30	77	32	28	42	0
15.5	1300	440	20	35	100	130	810	110	20	40	0	14	119	400
16.0	320	40	0	0	100	0	210	180	40	261	12	0	42	90
16.5	710	50	0	0	40	130	120	270	60	7	0	14	49	0
17.0	1630	70	135	5	100	0	210	150	20	77	16	42	56	650
17.5	450	240	25	5	120	90	100	0	30	101	8	49	28	0
18.0	370	0	50	80	0	0	40	200	10	25	32	35	21	0
18.5	110	70	5	0	40	80	260	200	70	32	30	0	63	90
19.0	430	150	50	60	80	120	120	20	20	31	0	14	0	390
19.5	580	0	0	0	60	60	90	140	0	50	52	0	0	0
20.0	2440	380	0	40	0	10	70	360	30	97	10	7	133	0
20.5	1110	440	20	0	170	70	130	190	130	50	40	7	21	0
21.0	2350	0	10	175	10	150	210	240	30	125	2	28	84	590
21.5	2080	80	15	0	110	110	170	90	10	112	32	0	154	0
22.0	400	180	0	10	30	0	130	40	0	7	24	28	49	400
22.5	160	450	30	0	40	10	160	80	20	23	8	49	105	0
23.0	3180	150	10	75	10	60	80	250	40	68	2	0	63	410
23.5	2080	60	35	5	220	100	190	110	50	200	42	35	70	0
24.0	860	160	15	0	0	50	120	350	100	52	6	28	77	480
24.5	30	300	0	0	0	0	250	120	60	76	36	0	70	0
25.0	2550	0	0	15	130	90	170	310	0	29	8	7	7	550
25.5	1250	330	10	0	60	100	0	120	50	235	100	119	119	0
26.0	1290	230	0	0	90	70	270	20	30	10	18	0	7	60
26.5	1220	0	60	0	130	30	170	110	80	5	36	14	77	40
27.0	400	0	0	0	0	300	430	60	0	58	60	35	133	410
27.5	1690	0	0	10	0	60	250	260	0	15	38	0	7	0
28.0	1070	920	30	10	220	130	40	60	160	230	86	7	238	0
28.5	80	60	10	0	120	0	90	80	30	120	34	63	98	0
29.0	820	0	40	0	20	60	180	20	90	27	12	70	105	500
29.5	460	0	5	5	290	30	70	150	20	42	8	7	42	0
30.0	2140	140	5	0	0	90	330	130	0	28	4	0	154	980
30.5	240	130	0	5	80	10	150	30	10	3	0	35	126	480
31.0	1080	30	0	0	70	120	120	230	70	144	122	49	56	0
31.5	780	520	0	0	0	120	130	190	30	44	28	49	35	490
32.0	2860	340	65	20	120	230	40	0	30	89	2	0	147	0
32.5	1440	240	5	10	300	110	210	10	170	82	0	7	112	0

33.0	940	80	5	0	0	100	300	190	10	37	26	7	42	400
33.5	250	0	15	0	10	100	200	30	20	24	0	14	28	0
34.0	350	60	0	0	150	120	50	130	60	172	70	7	147	10
34.5	750	780	0	0	160	130	480	200	60	129	98	28	42	0
35.0	2770	0	45	80	290	50	50	20	20	95	10	14	196	720
35.5	1360	220	0	0	240	20	60	250	10	46	0	7	140	110
36.0	100	80	0	0	70	180	120	170	50	17	64	35	98	310
36.5	270	500	20	0	0	50	240	130	40	258	16	42	0	30
37.0	790	40	0	5	280	0	300	110	190	57	92	0	371	490
37.5	1150	40	0	0	30	10	70	70	10	7	4	0	7	50
38.0	2130	0	0	0	40	90	80	133	10	21	4	0	28	0
38.5	0	70	0	15	10	0	170	220	10	77	10	42	49	0
39.0	1480	170	105	0	170	50	140	160	10	49	78	0	133	980
39.5	1100	0	10	15	100	70	210	120	40	37	82	63	126	0
40.0	600	60	90	0	30	50	620	100	40	138	14	56	105	0
40.5	0	360	20	20	70	0	60	150	80	75	122	0	70	80
41.0	1840	0	10	0	190	180	310	400	0	93	34	35	203	340
41.5	10	170	95	0	0	20	310	130	60	208	42	7	0	30
42.0	1130	110	10	0	130	120	130	100	40	2	14	14	497	40
42.5	500	910	15	0	240	90	600	20	50	114	42	0	105	0
43.0	2140	70	20	0	120	60	20	290	70	47	10	28	49	900
43.5	90	120	0	0	90	130	170	260	20	191	0	0	273	0
44.0	590	140	10	0	40	90	180	140	40	33	74	7	14	0
44.5	470	180	80	15	90	170	110	210	50	102	72	35	98	0
45.0	1730	260	0	10	90	0	410	40	50	94	20	35	189	170
45.5	70	90	0	5	60	50	150	180	60	32	2	0	21	820
46.0	1650	270	0	5	150	90	120	201	110	52	32	0	154	20
46.5	580	20	0	10	120	100	300	10	40	91	0	49	168	700
47.0	720	20	0	0	40	50	80	160	130	189	44	0	56	0
47.5	180	780	80	0	460	10	440	60	50	83	8	28	266	0
48.0	1220	0	0	0	0	270	70	450	20	64	26	7	0	450
48.5	570	330	30	0	0	70	110	10	90	208	62	0	0	230
49.0	250	330	5	0	200	60	300	100	10	44	70	21	259	170
49.5	1720	290	5	0	50	20	200	340	0	138	22	14	98	0
50.0	0	0	75	0	80	340	210	20	50	79	0	56	91	120
50.5	1690	290	15	0	0	110	0	100	10	35	12	21	28	400
51.0	570	0	0	10	20	50	130	130	70	28	18	0	91	0

	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B12
Sample Mean	40.36	9.67	37.80	1.38	42.73	23.57	13.22	82.25	8.21	34.71	4.57
Sample S.D.	52.39	15.52	57.94	4.40	59.44	31.94	24.84	89.44	24.73	79.44	15.66
Ex Post Mean	26.57	2.65	19.47	1.26	41.27	44.51	9.80	56.96	7.06	22.16	5.93
Ex Post S.D.	35.72	5.48	31.39	2.97	53.32	59.15	21.11	60.51	23.49	56.84	19.62
Overall Mean	36.27	7.59	32.37	1.34	42.30	29.78	12.21	74.75	7.87	30.99	4.97
Overall S.D.	48.41	13.72	52.15	4.03	57.62	42.88	23.81	82.66	24.34	73.61	16.92
Half-Week #											
0.5	50	0	20	0	80	60	0	136	0	0	0
1.0	0	5	0	0	0	0	0	28	0	0	60
1.5	10	0	150	0	60	90	0	0	0	0	0
2.0	160	35	0	4	30	0	110	270	0	80	70
2.5	120	0	0	4	0	0	40	58	0	0	20
3.0	0	0	80	0	0	100	100	440	0	0	0
3.5	70	0	120	0	50	100	10	44	0	0	5
4.0	0	55	20	4	70	0	20	40	0	40	20
4.5	0	25	80	0	140	0	20	0	0	0	0
5.0	180	10	0	0	170	0	0	0	80	0	40
5.5	0	45	10	0	0	0	0	0	0	160	25
6.0	40	5	0	0	100	10	0	0	0	0	0
6.5	20	0	30	0	80	160	20	202	0	0	0
7.0	60	25	50	0	40	20	0	0	0	0	0
7.5	80	40	120	0	0	80	10	334	0	360	0
8.0	50	0	10	0	10	0	10	0	0	0	0
8.5	40	0	90	4	30	30	0	0	0	0	0
9.0	40	10	148	0	20	120	30	198	0	0	25
9.5	0	25	0	0	0	10	30	8	0	0	0
10.0	20	0	80	0	0	0	0	234	0	0	0
10.5	30	0	30	0	0	60	0	0	40	0	0
11.0	20	65	0	0	8	0	0	72	40	200	0
11.5	10	5	0	0	0	0	0	524	0	0	0
12.0	20	0	0	0	0	0	0	0	0	0	0
12.5	150	35	0	8	0	0	0	112	0	0	0
13.0	20	0	0	0	0	0	10	0	0	0	0
13.5	20	10	0	0	0	0	0	186	0	0	0
14.0	0	0	0	0	0	0	0	34	0	0	0
14.5	0	0	0	0	0	13	0	136	0	80	0
15.0	0	20	0	0	0	0	0	166	0	0	0
15.5	0	10	0	0	0	0	50	34	0	0	0
16.0	8	0	0	0	0	0	30	66	0	0	0
16.5	0	0	0	0	0	60	0	8	0	0	0
17.0	0	0	0	0	19	0	0	56	0	0	0
17.5	0	40	0	0	0	20	0	110	0	0	0
18.0	0	0	0	0	0	80	30	0	0	80	0
18.5	0	15	0	0	0	30	0	26	0	0	0
19.0	80	0	0	0	0	30	0	104	0	0	0
19.5	30	35	0	0	0	0	50	88	0	0	0
20.0	10	0	0	0	0	10	0	26	0	0	0
20.5	60	15	30	12	120	40	0	96	0	0	0
21.0	70	5	50	0	340	0	30	42	0	0	0
21.5	30	0	150	0	30	0	50	212	0	320	0
22.0	0	50	0	0	70	0	0	38	0	0	0
22.5	0	25	40	0	190	20	0	104	0	0	0
23.0	40	0	0	0	0	0	0	0	0	0	0
23.5	60	5	0	0	0	0	10	104	0	0	0
24.0	30	0	110	20	120	30	10	134	0	0	0
24.5	20	0	150	0	110	0	0	88	40	0	0
25.0	60	20	10	0	0	20	0	34	0	0	0
25.5	30	30	10	0	20	10	0	0	0	0	0
26.0	0	0	10	0	80	0	0	86	0	0	0
26.5	90	0	60	0	30	0	0	0	0	0	0
27.0	0	15	30	0	0	70	0	290	0	0	0
27.5	100	15	10	0	40	10	0	54	0	0	0

28.0	90	5	40	0	30	0	10	112	0	160	0
28.5	30	0	0	0	40	20	30	192	0	0	0
29.0	50	0	10	0	50	30	0	20	0	80	0
29.5	60	50	30	0	120	0	90	190	0	360	0
30.0	40	0	230	20	50	0	0	6	0	0	0
30.5	40	10	40	0	10	0	10	108	0	0	0
31.0	170	5	40	0	50	40	0	148	0	0	0
31.5	30	0	0	0	230	50	20	204	0	360	0
32.0	160	10	130	0	0	10	10	16	0	0	0
32.5	0	5	0	0	30	50	0	194	0	200	0
33.0	20	20	50	25	40	0	0	0	0	0	0
33.5	10	0	20	0	0	30	0	84	0	0	0
34.0	70	20	20	0	60	10	0	26	0	0	0
34.5	10	30	40	0	20	180	50	334	0	0	10
35.0	110	0	60	0	160	50	0	0	0	160	10
35.5	0	0	10	0	120	10	0	0	0	0	0
36.0	50	0	20	0	0	10	10	82	0	0	0
36.5	40	20	80	0	0	130	0	158	0	0	0
37.0	40	0	0	0	40	0	140	102	80	80	0
37.5	40	0	20	0	0	0	30	184	0	0	0
38.0	0	0	30	0	70	0	0	0	80	0	0
38.5	0	0	0	0	240	60	10	116	0	320	0
39.0	20	0	80	0	0	0	0	166	0	0	20
39.5	0	45	0	0	20	50	50	194	0	0	0
40.0	60	0	160	0	60	0	0	264	0	0	0
40.5	0	0	20	0	100	20	0	82	0	0	0
41.0	90	10	80	8	0	70	30	124	0	0	30
41.5	200	0	40	0	20	0	20	164	0	0	0
42.0	40	10	10	0	40	80	0	0	0	0	0
42.5	40	0	10	0	40	40	0	86	0	0	20
43.0	0	20	30	0	20	20	40	78	0	0	0
43.5	70	0	140	0	20	0	10	0	0	0	0
44.0	120	100	0	0	70	0	0	90	0	240	0
44.5	30	10	10	0	20	0	0	112	0	0	20
45.0	50	0	0	0	10	60	20	48	40	0	0
45.5	10	0	0	0	0	20	0	92	0	0	0
46.0	30	0	40	8	70	0	10	0	0	0	0
46.5	0	5	0	0	0	0	100	20	0	0	20
47.0	80	15	100	0	190	20	0	136	0	0	0
47.5	10	5	180	0	0	30	0	16	0	120	0
48.0	10	5	0	24	130	40	0	104	0	40	0
48.5	160	0	0	0	60	0	0	38	0	120	0
49.0	0	0	120	0	0	0	20	120	0	0	0
49.5	0	10	10	0	0	10	0	0	0	0	10
50.0	140	0	0	0	0	60	0	194	80	160	0
50.5	30	15	160	0	40	60	40	18	0	0	0
51.0	20	0	0	0	40	10	0	126	0	40	0
51.5	80	0	30	0	10	0	0	88	0	40	0
52.0	110	0	0	0	10	0	0	6	0	160	0
52.5	0	25	100	0	0	30	0	146	0	80	0
53.0	200	15	0	0	30	40	10	0	0	0	0
53.5	0	0	0	0	0	10	0	262	0	140	0
54.0	50	0	50	0	90	0	0	0	0	179	0
54.5	0	0	220	0	84	70	40	188	0	0	0
55.0	80	35	0	0	0	0	0	14	0	0	0
55.5	0	0	10	0	220	60	10	158	0	0	0
56.0	0	25	10	0	80	20	0	20	160	160	0
56.5	0	0	10	0	0	10	0	44	0	0	0
57.0	30	0	20	0	0	30	0	0	0	0	100
57.5	10	35	350	0	0	30	140	52	0	100	0
58.0	10	0	0	0	110	0	0	62	0	20	0
58.5	30	20	80	0	40	0	0	106	40	0	0
59.0	80	0	0	0	0	30	0	0	0	0	10

59.5	0	5	140	0	0	60	10	166	0	20	5
60.0	240	0	0	0	180	0	0	34	0	140	15
60.5	0	0	80	0	30	20	0	110	40	120	0
61.0	160	20	30	0	20	20	0	90	0	0	0
61.5	0	5	0	0	220	70	0	80	80	0	0
62.0	90	5	100	0	0	0	0	114	0	0	20
62.5	40	80	140	0	50	0	20	248	0	0	5
63.0	30	0	10	0	20	20	0	14	0	0	5
63.5	130	20	0	0	0	30	0	22	40	0	0
64.0	0	0	60	0	0	70	0	108	0	200	0
64.5	80	15	0	0	60	0	0	170	0	0	0
65.0	0	0	250	0	0	50	10	108	80	160	0
65.5	10	0	50	0	20	0	0	36	0	0	30
66.0	0	0	30	0	0	10	10	66	0	0	0
66.5	0	5	0	0	10	90	40	100	0	0	0
67.0	50	0	160	0	20	0	50	64	0	240	20
67.5	0	40	120	0	30	20	0	0	0	0	0
68.0	130	20	0	0	0	20	0	144	0	0	0
68.5	20	0	0	8	190	30	50	94	0	0	0
69.0	0	0	100	0	100	0	0	152	0	0	0
69.5	30	10	20	0	20	0	50	96	0	0	0
70.0	40	0	30	0	40	110	20	0	0	0	5
70.5	10	0	110	0	40	0	0	78	0	120	0
71.0	10	0	10	0	30	20	0	26	0	0	0
71.5	110	0	20	0	10	0	60	90	0	0	5
72.0	60	35	90	0	0	40	0	34	40	320	0
72.5	10	0	0	0	10	60	30	0	0	40	0
73.0	70	35	10	0	40	0	0	280	0	120	120
73.5	70	0	0	0	0	20	40	66	0	0	0
74.0	60	5	70	0	20	10	0	208	80	0	0
74.5	180	20	0	0	0	0	110	284	0	0	0
75.0	10	0	60	0	0	0	0	32	40	0	0
75.5	60	10	0	0	0	20	0	170	0	0	0
76.0	20	0	40	16	50	70	10	46	0	320	0
76.5	0	5	0	0	100	90	0	160	0	0	0
77.0	0	0	20	0	0	0	0	16	0	0	0
77.5	10	15	10	0	60	20	30	214	0	0	0
78.0	0	10	10	4	40	0	0	38	0	0	0
78.5	0	0	10	8	0	30	10	0	40	0	0
79.0	120	5	0	0	0	0	0	502	0	0	0
79.5	20	60	40	0	50	0	10	164	0	120	0
80.0	40	0	40	0	10	20	0	0	0	0	0
80.5	40	25	30	0	110	0	0	2	0	0	0
81.0	0	0	0	0	30	0	0	162	0	0	0
81.5	60	20	10	0	80	0	20	0	40	0	20
82.0	30	0	60	0	260	30	0	104	0	0	0
82.5	90	5	60	0	110	30	40	50	0	0	0
83.0	10	5	60	0	10	20	50	48	0	0	0
83.5	50	25	0	0	10	20	20	22	0	0	0
84.0	0	0	0	0	20	90	0	100	0	0	0
84.5	80	0	20	0	60	0	0	0	108	0	0
85.0	0	5	0	0	60	20	0	118	0	0	0
85.5	0	0	0	0	0	40	0	126	0	0	0
86.0	20	40	110	0	90	0	0	0	0	0	0
86.5	30	10	0	0	230	20	30	66	0	0	0
87.0	170	15	230	0	0	50	0	26	0	0	15
87.5	40	50	30	0	40	0	0	22	0	0	0
88.0	0	0	0	10	100	40	20	182	0	0	0
88.5	0	10	0	0	10	0	0	74	0	0	20
89.0	10	15	0	24	10	0	0	56	0	0	0
89.5	220	25	0	0	50	30	100	10	0	0	90
90.0	70	0	280	24	60	0	0	172	120	0	0
90.5	0	20	10	4	30	70	0	108	0	0	0

91.0	20	10	10	0	50	0	0	114	0	160	0
91.5	160	10	40	0	70	0	0	6	0	0	0
92.0	0	15	0	0	0	20	10	172	80	0	0
92.5	0	25	40	0	140	0	10	26	0	40	0
93.0	40	0	200	0	0	80	0	116	0	0	0
93.5	20	10	60	0	0	10	0	38	160	0	15
94.0	20	0	0	0	170	0	10	204	0	0	5
94.5	30	5	0	20	0	0	30	26	0	80	0
95.0	20	5	0	0	30	50	10	192	0	0	25
95.5	60	0	170	0	60	0	70	4	0	0	0
96.0	0	20	0	8	0	80	0	110	0	0	0
96.5	20	0	70	0	100	0	0	106	0	0	0
97.0	50	0	10	8	0	0	10	124	0	0	0
97.5	40	0	0	0	80	0	20	36	40	0	0
98.0	40	5	20	0	0	0	0	184	0	200	0
98.5	0	0	30	0	50	0	0	282	0	0	0
99.0	10	5	10	0	0	80	20	0	0	0	0
99.5	40	0	0	0	140	30	0	146	40	0	0
100.0	0	50	80	0	0	30	10	18	0	0	0
100.5	0	35	0	7	0	0	0	30	0	160	0
101.0	240	0	110	1	150	0	80	222	0	0	100
101.5	20	0	60	0	0	30	10	24	0	60	0
102.0	0	0	0	0	20	0	10	188	0	100	0
102.5	30	0	40	0	20	20	0	122	0	0	0
103.0	80	0	0	0	120	30	40	38	0	0	0
103.5	0	0	0	4	70	0	0	0	0	40	0
104.0	80	30	20	0	240	0	0	34	0	0	0
104.5	70	0	0	0	0	70	0	12	0	40	0
105.0	10	20	0	0	10	0	40	12	0	0	0
105.5	10	0	200	8	50	0	0	6	0	0	0
106.0	10	0	0	0	10	20	40	18	40	0	0
106.5	40	20	30	0	0	60	10	16	0	0	50
107.0	0	0	10	0	170	70	0	20	0	160	0
107.5	0	5	0	0	0	0	0	0	0	0	0
108.0	20	0	0	0	0	0	0	0	40	0	0
108.5	10	0	0	0	30	50	0	0	0	0	0
109.0	20	0	50	0	20	0	0	68	40	0	0
109.5	50	0	0	0	20	50	0	0	0	400	0
110.0	0	0	60	4	0	20	0	0	80	0	0
110.5	0	0	10	0	10	0	60	0	0	0	0
111.0	300	15	0	0	0	10	0	0	0	0	0
111.5	0	0	60	0	70	30	0	2	0	0	0
112.0	0	0	0	0	0	30	0	0	0	0	0
112.5	0	5	0	3	20	60	50	14	0	0	0
113.0	40	0	50	5	10	0	10	32	0	0	0
113.5	0	0	20	0	50	20	20	10	40	0	0
114.0	40	0	0	0	0	0	0	44	0	0	0
114.5	0	0	0	0	20	20	10	0	0	0	0
115.0	50	0	0	0	0	0	0	0	0	0	0
115.5	20	0	0	0	0	30	0	54	0	0	0
116.0	0	0	50	18	10	0	0	34	0	0	0
116.5	0	0	0	0	50	70	70	96	0	0	5
117.0	40	20	30	4	20	0	0	14	0	240	5
117.5	20	40	120	0	0	140	0	76	0	0	0
118.0	0	0	0	4	0	0	0	0	0	0	0
118.5	10	0	0	0	110	10	70	54	0	160	10
119.0	0	0	0	0	0	10	0	22	0	0	0
119.5	0	20	80	0	160	10	0	12	0	0	0
120.0	130	0	0	0	0	40	10	48	0	0	0
120.5	60	0	0	0	60	0	0	54	0	0	0
121.0	90	0	10	0	50	60	10	36	40	0	0
0.5	0	0	0	0	0	20	0	24	40	120	5
1.0	0	0	0	0	120	0	10	32	0	0	0

1.5	0	0	0	4	100	10	0	66	0	0	0
2.0	70	0	0	0	0	0	50	28	0	0	0
2.5	40	5	0	0	60	60	20	142	0	160	40
3.0	80	0	130	4	40	10	0	66	0	0	0
3.5	0	0	50	0	0	0	10	34	40	0	0
4.0	160	0	0	0	30	50	0	0	0	0	0
4.5	50	15	0	0	90	0	50	0	0	80	30
5.0	0	0	0	0	0	90	0	66	0	0	0
5.5	20	0	0	0	50	0	20	6	0	80	20
6.0	20	5	0	0	10	20	0	0	0	0	0
6.5	0	0	100	0	0	50	0	32	80	0	0
7.0	120	10	0	0	0	0	0	4	0	0	0
7.5	50	0	0	0	170	0	0	88	0	0	0
8.0	0	5	190	4	0	20	10	302	0	0	0
8.5	0	0	20	0	60	0	20	18	0	0	0
9.0	10	0	10	0	50	0	0	14	0	0	0
9.5	20	0	0	1	0	0	0	42	0	0	0
10.0	10	30	0	11	50	0	0	24	0	0	0
10.5	10	0	70	0	210	0	0	16	0	0	0
11.0	70	0	90	0	0	0	10	38	0	0	0
11.5	30	0	60	4	0	90	0	20	0	0	0
12.0	20	0	0	0	30	0	140	12	0	0	0
12.5	30	0	0	0	10	0	0	42	0	0	0
13.0	0	20	20	8	0	0	0	22	0	0	0
13.5	20	20	10	11	0	10	0	2	0	80	0
14.0	10	0	10	1	0	120	20	28	0	40	0
14.5	0	5	20	0	10	40	10	30	40	0	0
15.0	0	0	0	12	0	10	0	0	0	0	0
15.5	90	0	0	0	80	0	20	0	0	0	15
16.0	10	0	10	4	0	130	10	42	0	0	0
16.5	60	15	50	0	30	40	0	28	0	0	50
17.0	0	10	0	12	50	150	0	0	0	0	0
17.5	0	0	0	0	30	0	20	0	0	0	0
18.0	0	0	0	0	20	60	0	66	0	0	0
18.5	10	0	30	0	90	200	0	8	0	120	0
19.0	20	0	50	0	0	0	0	40	0	0	0
19.5	0	0	10	0	70	40	0	0	0	0	0
20.0	10	10	0	0	30	110	0	80	0	0	50
20.5	0	0	10	0	0	0	30	0	0	0	0
21.0	40	0	0	0	20	150	10	80	0	120	0
21.5	30	0	20	4	170	0	10	112	0	0	0
22.0	30	0	0	0	0	100	0	0	0	0	0
22.5	0	0	0	0	50	20	0	16	0	0	0
23.0	80	0	30	0	0	70	0	38	0	120	0
23.5	120	5	30	0	60	0	0	102	80	40	0
24.0	0	0	0	0	10	230	10	32	0	0	0
24.5	10	0	50	0	20	40	10	68	40	0	0
25.0	10	0	60	3	20	10	0	94	0	0	0
25.5	0	5	10	0	10	0	70	32	0	40	0
26.0	0	15	20	0	30	10	30	42	0	0	0
26.5	10	0	10	0	220	0	0	136	0	0	35
27.0	20	0	0	1	220	170	20	0	0	80	0
27.5	70	0	30	4	0	60	0	38	0	40	0
28.0	120	5	0	0	50	0	10	130	0	40	0
28.5	80	0	40	0	90	140	0	44	0	0	0
29.0	0	0	0	0	0	0	0	50	0	40	0
29.5	40	15	0	0	0	40	0	0	0	0	0
30.0	10	5	10	4	0	40	0	172	0	0	0
30.5	0	0	10	0	200	70	0	26	80	0	0
31.0	70	0	10	4	0	0	20	200	0	0	0
31.5	20	10	0	0	30	0	0	6	0	0	0
32.0	10	0	0	0	40	40	10	144	0	160	5
32.5	10	10	0	0	0	10	0	0	0	0	0

33.0	10	0	0	0	30	50	0	158	0	0	0
33.5	10	0	10	0	0	0	0	12	0	0	0
34.0	0	0	50	0	110	180	0	122	0	0	100
34.5	0	0	50	0	50	190	20	182	0	0	0
35.0	40	0	0	0	0	0	0	4	0	0	0
35.5	10	0	20	0	10	10	0	58	0	0	0
36.0	50	5	0	0	40	0	20	32	0	160	105
36.5	10	0	0	4	0	10	40	0	0	0	0
37.0	70	0	70	0	50	100	0	240	80	0	0
37.5	120	0	0	0	40	0	0	0	0	0	0
38.0	0	0	10	0	10	0	0	60	0	0	0
38.5	20	5	0	0	80	150	0	104	0	0	0
39.0	0	0	10	0	60	0	100	20	0	0	0
39.5	0	0	0	5	50	20	0	92	0	0	0
40.0	0	0	0	0	20	30	0	0	0	0	0
40.5	10	0	20	0	110	100	0	144	0	0	0
41.0	20	0	0	0	10	0	0	0	0	0	0
41.5	150	0	0	0	60	80	10	92	0	0	0
42.0	40	0	50	0	0	30	0	166	0	0	0
42.5	80	0	10	0	0	20	20	46	40	0	0
43.0	0	5	10	0	20	100	10	104	0	300	0
43.5	30	5	30	5	100	130	0	112	0	120	0
44.0	20	0	20	0	0	10	0	0	0	0	0
44.5	60	0	0	0	0	120	0	54	0	0	0
45.0	10	5	40	0	0	0	0	122	0	320	0
45.5	30	0	66	4	50	190	0	94	0	0	0
46.0	0	10	0	0	70	10	20	40	0	0	55
46.5	10	0	0	0	60	20	20	54	0	0	0
47.0	10	0	0	0	0	50	0	84	160	0	0
47.5	20	0	90	0	110	160	20	46	0	0	95
48.0	20	0	40	0	0	0	0	148	0	0	0
48.5	0	0	30	0	20	170	0	172	0	0	0
49.0	0	0	10	0	20	30	0	0	40	0	0
49.5	40	0	70	0	160	0	70	0	0	0	0
50.0	0	0	10	15	120	40	0	142	0	0	0
50.5	0	15	0	0	0	10	0	0	0	0	0
51.0	0	0	0	0	20	0	0	82	0	0	0

Simulation Results - Existing Policy

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	4142.549	22680.46	61	1.000	1
A02	7.075	665.882	4711.12	53	0.964	1
A03	31.205	71.373	2227.19	48	0.904	1
A04	33.906	83.284	2823.83	24	0.954	1
A05	6.049	270.980	1639.16	63	0.996	1
A06	6.703	283.235	1898.52	66	0.998	1
A07	9.161	793.333	7267.72	70	1.000	1
A08	17.468	682.275	11917.98	66	1.000	1
A09	10.987	161.275	1771.93	65	0.998	1
A10	17.164	345.745	5934.37	65	0.991	1
A11	57.509	101.529	5838.83	61	0.942	1
A12	35.970	80.637	2900.51	52	0.997	1
A13	20.977	330.922	6941.75	65	0.952	1
A14	5.292	775.098	4101.82	50	0.974	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			82655.19	809	0.976	1.000
B01	9.744	94.216	918.04	46	0.830	0
B02	22.467	10.490	235.68	22	0.778	0
B03	7.689	62.882	483.50	40	0.785	0
B04	63.440	4.706	298.55	25	0.636	0
B05	10.928	121.177	1324.22	51	0.843	0
B06	11.360	116.863	1327.56	52	0.879	0
B07	6.916	35.980	248.84	33	0.750	0
B08	70.470	140.569	9905.90	68	0.935	1
B09	3.106	31.373	97.44	11	0.556	0
B10	3.576	86.471	309.22	23	0.602	0
B12	28.399	21.275	604.19	20	0.430	0
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			15753.14	391	0.729	0.091
			Total	Total	Average	Total % Meeting 90%
			98408.33	1200	0.868	0.600

	Alpha	Z	d	P
A01	0.053	1942.13	1	1.0003
A02	0.035	276.06	1	1.0205
A03	0.090	45.64	2	1.1597
A04	0.060	62.64	2	1.0740
A05	0.093	110.92	1	1.0304
A06	0.078	138.40	1	1.0005
A07	0.047	442.12	1	1.0000
A08	0.172	437.08	1	1.0000
A09	0.074	78.26	1	1.0006
A10	0.049	201.34	1	1.0000
A11	0.141	41.36	1	1.1690
A12	0.032	39.25	1	1.1136
A13	0.014	153.71	1	1.0251
A14	0.063	403.31	1	1.0651
B01	0.013	84.53	1	1.0360
B02	0.053	22.14	2	1.5047
B03	0.028	79.49	1	1.1509
B04	0.076	9.11	4	3.0303
B05	0.008	93.19	1	1.1648
B06	0.047	53.57	1	1.1521
B07	0.030	36.88	1	1.4011
B08	0.164	79.86	1	1.1776
B09	0.143	56.91	1	3.4576
B10	0.053	165.17	3	2.5910
B12	0.026	30.27	3	2.6915

	MvAvg MSE	Naive MSE	% Diff	Mean MSE	% Diff	Croston MSE	% Diff
A01	1121244.51	2189474.51	0.95	2622322.19	1.34	1084032.66	-0.03
A02	70674.52	172766.67	1.44	120198.47	0.70	70187.93	-0.01
A03	1288.07	2278.92	0.77	1207.58	-0.06	1261.72	-0.02
A04	1703.79	3498.04	1.05	1738.13	0.02	1799.73	0.06
A05	8090.67	15537.25	0.92	22034.13	1.72	8529.13	0.05
A06	6220.22	10888.24	0.75	16621.66	1.67	6065.49	-0.02
A07	49696.75	98488.24	0.98	83616.57	0.68	47345.25	-0.05
A08	29552.67	50387.84	0.71	47289.51	0.60	26922.41	-0.09
A09	3319.97	6507.84	0.96	3211.24	-0.03	3117.15	-0.06
A10	11705.68	20807.71	0.78	13351.72	0.14	10775.47	-0.08
A11	1829.78	2906.90	0.59	1672.23	-0.09	1659.12	-0.09
A12	1040.44	2418.29	1.32	1463.10	0.41	1000.54	-0.04
A13	15015.78	23305.75	0.55	26278.86	0.75	14720.43	-0.02
A14	79470.31	189066.67	1.38	117962.83	0.48	75355.84	-0.05
		Avg % Diff	0.94	**Avg % Diff**	0.60	**Avg % Diff**	-0.03
B01	2425.25	3805.88	0.57	2290.58	-0.06	2612.46	0.08
B02	61.18	131.86	1.16	76.41	0.25	82.49	0.35
B03	2035.08	3735.92	0.84	1868.33	-0.08	2218.13	0.09
B04	17.39	27.33	0.57	16.52	-0.05	15.55	-0.11
B05	6490.78	14476.47	1.23	7408.36	0.14	5863.66	-0.10
B06	4332.85	7307.84	0.69	8496.92	0.96	4462.99	0.03
B07	864.66	1915.69	1.22	840.61	-0.03	834.26	-0.04
B08	5016.01	9250.82	0.84	6267.06	0.25	4891.71	-0.02
B09	1071.49	2227.45	1.08	1027.69	-0.04	1012.43	-0.06
B10	6184.34	11278.43	0.82	5697.22	-0.08	5856.01	-0.05
B12	769.61	1612.75	1.10	745.36	-0.03	699.34	-0.09
		Avg % Diff	0.92	**Avg % Diff**	0.11	**Avg % Diff**	0.01
Overall Average % Difference			0.93		0.38		-0.01

Simulation Results - Naive Forecast

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	5517.647	30209.12	32	0.998	1
A02	7.075	1333.333	9433.33	20	0.987	1
A03	31.205	168.529	5258.95	21	0.880	0
A04	33.906	276.177	9364.06	8	0.919	1
A05	6.049	411.078	2486.61	31	0.996	1
A06	6.703	403.333	2703.54	37	0.979	1
A07	9.161	1165.000	10672.57	31	0.973	1
A08	17.468	881.000	15389.31	34	1.000	1
A09	10.987	322.941	3548.15	24	1.000	1
A10	17.164	545.873	9369.36	38	1.000	1
A11	57.509	193.451	11125.17	32	0.981	1
A12	35.970	152.628	5490.03	24	0.983	1
A13	20.977	497.206	10429.89	43	0.942	1
A14	5.292	1366.275	7230.33	28	0.994	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			132710.42	403	0.974	0.929
B01	9.744	219.118	2135.09	15	0.963	1
B02	22.467	27.892	626.65	13	0.944	1
B03	7.689	167.333	1286.62	16	0.894	0
B04	63.440	12.794	811.65	16	0.876	0
B05	10.928	283.039	3093.05	20	0.943	1
B06	11.360	204.902	2327.69	32	0.958	1
B07	6.916	162.059	1120.80	8	0.900	1
B08	70.470	341.549	24068.96	35	0.979	1
B09	3.106	161.177	500.62	6	1.000	1
B10	3.576	295.882	1058.07	14	0.938	1
B12	28.399	119.902	3405.10	12	0.926	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			40434.29	187	0.938	0.818
			Total	Total	Average	Total % Meeting 90%
			173144.71	590	0.958	0.880

Simulation Results - Mean Forecast

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	620.980	3399.87	82	0.693	0
A02	7.075	120.882	855.24	69	0.562	0
A03	31.205	61.814	1928.91	42	0.924	1
A04	33.906	59.853	2029.38	27	0.799	0
A05	6.049	31.373	189.78	78	0.521	0
A06	6.703	36.177	242.49	79	0.660	0
A07	9.161	230.490	2111.52	88	0.868	0
A08	17.468	214.333	3743.97	78	0.932	1
A09	10.987	119.216	1309.83	68	0.987	1
A10	17.164	201.735	3462.58	72	0.921	1
A11	57.509	148.961	8566.60	53	1.000	1
A12	35.970	20.931	752.89	57	0.724	0
A13	20.977	79.265	1662.74	77	0.737	0
A14	5.292	211.471	1119.10	52	0.794	0
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			31374.88	922	0.794	0.357
B01	9.744	53.922	525.42	51	0.731	0
B02	22.467	18.529	416.29	17	0.889	0
B03	7.689	56.804	436.77	53	0.780	0
B04	63.440	1.824	115.71	23	0.403	0
B05	10.928	44.804	489.62	59	0.672	0
B06	11.360	15.882	180.42	53	0.359	0
B07	6.916	17.353	120.01	37	0.600	0
B08	70.470	98.333	6929.53	69	0.903	1
B09	3.106	15.686	48.72	6	0.389	0
B10	3.576	55.294	197.73	20	0.496	0
B12	28.399	7.647	217.17	13	0.198	0
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			9677.38	401	0.584	0.091
			Total	Total	Average	Total % Meeting 90%
			41052.27	1323	0.702	0.240

Simulation Results - Croston Forecast

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	4034.314	22087.87	66	1.000	1
A02	7.075	549.314	3886.40	54	0.957	1
A03	31.205	73.480	2292.94	43	0.930	1
A04	33.906	102.206	3465.40	23	0.975	1
A05	6.049	257.843	1559.69	62	0.994	1
A06	6.703	276.471	1853.19	65	1.000	1
A07	9.161	830.392	7607.22	68	1.000	1
A08	17.468	679.137	11863.17	65	1.000	1
A09	10.987	160.294	1761.15	66	1.000	1
A10	17.164	382.912	6572.30	63	1.000	1
A11	57.509	104.529	6011.36	54	0.974	1
A12	35.970	72.333	2601.82	53	0.983	1
A13	20.977	281.510	5905.24	65	0.946	1
A14	5.292	762.255	4033.85	46	0.984	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			81501.59	793	0.982	1.000
B01	9.744	131.471	1281.05	42	0.959	1
B02	22.467	20.539	461.45	20	0.963	1
B03	7.689	104.647	804.63	35	0.967	1
B04	63.440	5.216	330.90	21	0.705	0
B05	10.928	119.706	1308.15	52	0.893	0
B06	11.360	82.157	933.30	49	0.833	0
B07	6.916	42.255	292.24	29	0.800	0
B08	70.470	148.235	10446.12	67	0.941	1
B09	3.106	31.373	97.44	11	0.611	0
B10	3.576	108.628	388.45	20	0.761	0
B12	28.399	21.225	602.77	12	0.463	0
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			16946.51	358	0.809	0.364
			Total	Total	Average	Total % Meeting 90%
			98448.10	1151	0.906	0.720

A01

Interval	Prob	O	E	Stat
0 thr 13	0.1620	38	39.2120	0.0375
14 thr 30	0.1656	36	40.0833	0.4160
31 thr 52	0.1680	46	40.6573	0.7021
53 thr 82	0.1643	38	39.7634	0.0782
83 thr 133	0.1666	41	40.3057	0.0120
134 thr inf	0.1735	43	41.9783	0.0249
				1.2705

A02

Interval	Prob	O	E	Stat
0 thr 1	0.1884	77	45.6013	21.6195
2 thr 3	0.1300	18	31.4704	5.7658
4 thr 7	0.1878	25	45.4587	9.2075
8 thr 12	0.1567	25	37.9126	4.3979
13 thr 21	0.1630	52	39.4515	3.9914
22 thr inf	0.1740	45	42.1056	0.1990
				45.1810

A03

Interval	Prob	O	E	Stat
0	0.2504	83	60.5853	8.2928
1	0.1245	13	30.1271	9.7367
2 thr 3	0.1576	34	38.1316	0.4477
4 thr 6	0.1442	29	34.8945	0.9957
7 thr 12	0.1542	42	37.3152	0.5882
13 thr inf	0.1692	41	40.9462	0.0001
				20.0611

A04

Interval	Prob	O	E	Stat
0	0.2170	98	52.5087	39.4118
1	0.1322	16	31.9990	7.9993
2 thr 3	0.1788	18	43.2578	14.7478
4 thr 6	0.1662	22	40.2127	8.2487
7 thr 11	0.1496	41	36.2011	0.6361
12 thr inf	0.1563	47	37.8207	2.2279
				73.2716

A05

Interval	Prob	O	E	Stat
0	0.2293	71	55.4965	4.3311
1	0.1446	32	35.0045	0.2579
2	0.1084	12	26.2368	7.7253
3 thr 4	0.1548	32	37.4515	0.7935
5 thr 9	0.2038	51	49.3240	0.0569
10 thr inf	0.1590	44	38.4867	0.7898
				13.9545

A06

Interval	Prob	O	E	Stat
0 thr 1	0.2307	60	55.8387	0.3101
2	0.1179	30	28.5436	0.0743
3 thr 4	0.1993	38	48.2329	2.1710
5 thr 6	0.1465	36	35.4481	0.0086
7 thr 9	0.1406	37	34.0320	0.2588
10 thr inf	0.1649	41	39.9046	0.0301
				2.8529

A07

Interval	Prob	O	E	Stat
0 thr 6	0.1645	48	39.8133	1.6834
7 thr 11	0.1729	41	41.8367	0.0167
12 thr 16	0.1607	30	38.8837	2.0297
17 thr 23	0.1780	32	43.0854	2.8522
24 thr 32	0.1493	44	36.1229	1.7177
33 thr inf	0.1746	47	42.2580	0.5321
				8.8318

A08

Interval	Prob	O	E	Stat
0 thr 3	0.1520	41	36.7842	0.4832
4 thr 8	0.1980	48	47.9185	0.0001
9 thr 13	0.1640	36	39.6835	0.3419
14 thr 19	0.1490	34	36.0677	0.1185
20 thr 30	0.1695	37	41.0140	0.3928
31 thr inf	0.1675	46	40.5321	0.7376
				2.0742

A09

Interval	Prob	O	E	Stat
0	0.1130	31	27.3374	0.4907
1 thr 2	0.1998	43	48.3454	0.5910
3 thr 5	0.2245	58	54.3296	0.2480
6 thr 8	0.1532	34	37.0758	0.2552
9 thr 13	0.1523	36	36.8581	0.0200
14 thr inf	0.1572	40	38.0537	0.0995
				1.7044

A10

Interval	Prob	O	E	Stat
0 thr 30	0.1623	45	39.2657	0.8374
31 thr 59	0.1642	38	39.7402	0.0762
60 thr 95	0.1726	37	41.7654	0.5437
96 thr 138	0.1561	34	37.7779	0.3778
139 thr 215	0.1733	42	41.9442	0.0001
216 thr inf	0.1715	46	41.5066	0.4864
				2.3217

A11

Interval	Prob	O	E	Stat
0 thr 5	0.1720	67	41.6143	15.4858
6 thr 12	0.1503	18	36.3752	9.2824
13 thr 23	0.1775	36	42.9664	1.1295
24 thr 38	0.1665	29	40.2926	3.1649
39 thr 63	0.1618	48	39.1552	1.9979
64 thr inf	0.1719	44	41.5962	0.1389
				31.1995

A12

Interval	Prob	O	E	Stat
0	0.3710	98	89.7834	0.7520
1	0.1760	38	42.5878	0.4942
2	0.1139	26	27.5572	0.0880
3 thr 4	0.1391	29	33.6598	0.6451
5 thr 7	0.1038	24	25.1190	0.0499
8 thr inf	0.0963	27	23.2929	0.5900
				2.6191

A13

Interval	Prob	O	E	Stat
0 thr 1	0.1440	45	34.8511	2.9554
2 thr 4	0.1901	36	46.0102	2.1779
5 thr 8	0.1946	40	47.0906	1.0676
9 thr 12	0.1396	34	33.7933	0.0013
13 thr 20	0.1689	48	40.8623	1.2468
21 thr inf	0.1628	39	39.3925	0.0039
				7.4529

A14

Interval	Prob	O	E	Stat
0	0.1166	83	28.2161	106.3672
1 thr 4	0.2172	26	52.5532	13.4164
5 thr 10	0.1829	29	44.2619	5.2625
11 thr 17	0.1358	11	32.8685	14.5498
18 thr 34	0.1795	37	43.4342	0.9531
35 thr inf	0.1680	56	40.6660	5.7820
				146.3310

B01

Interval	Prob	O	E	Stat
0	0.2634	77	63.7385	2.7592
1	0.1564	25	37.8391	4.3564
2	0.1131	24	27.3687	0.4146
3 thr 4	0.1550	42	37.5112	0.5372
5 thr 8	0.1649	41	39.8965	0.0305
9 thr inf	0.1473	33	35.6460	0.1964
				8.2943

B02

Interval	Prob	O	E	Stat
0	0.4584	129	110.9239	2.9457
1	0.1780	27	43.0763	5.9998
2	0.1057	18	25.5773	2.2448
3	0.0700	13	16.9383	0.9157
4 thr 5	0.0837	28	20.2560	2.9606
6 thr inf	0.1042	27	25.2282	0.1244
				15.1909

B03

Interval	Prob	O	E	Stat
0	0.3508	102	84.8960	3.4460
1	0.1493	29	36.1349	1.4088
2	0.0980	15	23.7233	3.2076
3 thr 4	0.1274	29	30.8331	0.1090
5 thr 8	0.1336	31	32.3431	0.0558
9 thr inf	0.1408	36	34.0697	0.1094
				8.3365

B04

Interval	Prob	O	E	Stat
0	0.7573	209	183.2654	3.6137
1	0.0739	1	17.8893	15.9452
2	0.0379	0	9.1833	9.1833
3 thr 4	0.0426	11	10.3043	0.0470
5 thr 9	0.0463	10	11.2030	0.1292
10 thr inf	0.0420	11	10.1548	0.0704
				28.9887

B05

Interval	Prob	O	E	Stat
0	0.2888	91	69.8963	6.3718
1	0.1493	19	36.1230	8.1166
2	0.1042	23	25.2114	0.1940
3 thr 4	0.1413	29	34.1924	0.7885
5 thr 8	0.1538	39	37.2154	0.0856
9 thr inf	0.1627	41	39.3615	0.0682
				15.6247

B06

Interval	Prob	O	E	Stat
0	0.3544	108	85.7678	5.7629
1	0.1929	20	46.6884	15.2558
2	0.1267	31	30.6595	0.0038
3	0.0879	24	21.2815	0.3473
4 thr 5	0.1081	18	26.1550	2.5427
6 thr inf	0.1299	41	31.4478	2.9015
				26.8140

B07

Interval	Prob	O	E	Stat
0	0.5737	147	138.8417	0.4794
1	0.1626	34	39.3492	0.7272
2	0.0869	15	21.0338	1.7309
3	0.0537	12	13.0041	0.0775
4 thr 5	0.0598	20	14.4661	2.1170
6 thr inf	0.0632	14	15.3050	0.1113
				5.2432

B08

Interval	Prob	O	E	Stat
0 thr 5	0.1633	59	39.5181	9.6043
6 thr 14	0.1701	31	41.1584	2.5072
15 thr 26	0.1654	29	40.0387	3.0434
27 thr 44	0.1693	28	40.9791	4.1108
45 thr 74	0.1617	47	39.1381	1.5793
75 thr inf	0.1701	48	41.1676	1.1339
				21.9790

B09

Interval	Prob	O	E	Stat
0	0.8623	211	208.6716	0.0260
1	0.0952	18	23.0347	1.1004
2	0.0273	9	6.5981	0.8743
3	0.0094	2	2.2772	0.0337
4	0.0035	2	0.8528	1.5434
5 thr inf	0.0023	0	0.5656	0.5656
				4.1435

B10

Interval	Prob	O	E	Stat
0	0.6229	187	150.7400	8.7222
1	0.1189	2	28.7712	24.9102
2	0.0643	8	15.5491	3.6651
3 thr 4	0.0724	8	17.5213	5.1740
5 thr 7	0.0540	10	13.0701	0.7212
8 thr inf	0.0676	27	16.3483	6.9402
				50.1328

B12

Interval	Prob	O	E	Stat
0	0.8005	202	193.7263	0.3534
1	0.0680	9	16.4625	3.3828
2	0.0337	5	8.1648	1.2267
3 thr 4	0.0363	13	8.7930	2.0128
5 thr 8	0.0319	6	7.7167	0.3819
9 thr inf	0.0295	7	7.1367	0.0026
				7.3601

Simulation Results - Existing Policy Over Sample Set (minus first 13 weeks) Attachment 11

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	2886.296	15802.47	137	0.990	1
A02	7.075	446.398	3158.27	114	0.968	1
A03	31.205	139.579	4355.55	96	0.989	1
A04	33.906	115.093	3902.33	104	0.974	1
A05	6.049	195.417	1182.08	113	0.965	1
A06	6.703	201.870	1353.14	133	0.983	1
A07	9.161	774.556	7095.70	143	1.000	1
A08	17.468	672.593	11748.85	143	0.997	1
A09	10.987	299.426	3289.79	120	0.985	1
A10	17.164	519.954	8924.49	143	0.986	1
A11	57.509	326.296	18764.97	112	0.997	1
A12	35.970	75.509	2716.07	93	0.930	1
A13	20.977	315.208	6612.12	130	0.980	1
A14	5.292	724.398	3833.51	106	0.972	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			92739.34	1687	0.980	1.000
B01	9.744	127.630	1243.62	106	0.922	1
B02	22.467	32.917	739.54	80	0.872	0
B03	7.689	129.444	995.30	92	0.853	0
B04	63.440	7.005	444.37	37	0.511	0
B05	10.928	139.769	1527.39	104	0.839	0
B06	11.360	70.194	797.41	105	0.928	1
B07	6.916	43.102	298.09	72	0.799	0
B08	70.470	272.444	19199.16	122	0.981	1
B09	3.106	34.815	108.13	26	0.591	0
B10	3.576	142.875	510.92	57	0.759	0
B12	28.399	27.917	792.81	31	0.565	0
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			26656.74	832	0.784	0.273
			Total	Total	Average	Total % Meeting 90%
			119396.09	2519	0.893	0.680

	c	Mean Hfwk Demand	lambda	SQRT of c*lambda	Resulting EOQ Value
A01	5.475	775.694	79120.829	658.169	751.407
A02	7.075	119.602	12199.394	293.787	259.554
A03	31.205	29.144	2972.639	304.567	61.007
A04	33.906	29.421	3000.973	318.984	58.805
A05	6.049	50.231	5123.611	176.048	181.915
A06	6.703	54.551	5564.195	193.124	180.090
A07	9.161	205.653	20976.586	438.368	299.101
A08	17.468	187.732	19148.613	578.349	206.952
A09	10.987	68.991	7037.055	278.058	158.190
A10	17.164	125.435	12794.390	468.618	170.656
A11	57.509	66.333	6766.000	623.784	67.799
A12	35.970	17.986	1834.583	256.885	44.640
A13	20.977	78.315	7988.111	409.349	121.975
A14	5.292	191.250	19507.500	321.300	379.501
B01	9.744	39.713	4050.722	198.671	127.444
B02	22.467	9.051	923.194	144.019	40.068
B03	7.689	37.546	3829.723	171.601	139.499
B04	63.440	1.431	145.917	96.213	9.480
B05	10.928	43.764	4463.917	220.866	126.331
B06	11.360	22.514	2296.417	161.516	88.871
B07	6.916	12.917	1317.500	95.456	86.272
B08	70.470	79.648	8124.111	756.641	67.113
B09	3.106	8.463	863.222	51.780	104.204
B10	3.576	34.995	3569.528	112.981	197.483
B12	28.399	3.889	396.667	106.136	23.361

Sum of SQRT's $\boxed{5257.529}$

Total # orders from Sample Set sim 2519

Avg # Replenishments / Year 1189.5278

K/I Estimate $\boxed{19.535034}$

Item	Desired Fillrate	s	S
A01	0.90	3010	3020
	0.95	3670	3680
	0.99	5140	5150
A02	0.90	430	560
	0.95	550	680
	0.99	830	960
A03	0.90	135	160
	0.95	175	200
	0.99	265	290
A04	0.90	125	150
	0.95	160	185
	0.99	240	265
A05	0.90	160	290
	0.95	210	340
	0.99	330	460
A06	0.90	130	260
	0.95	170	300
	0.99	260	390
A07	0.90	540	680
	0.95	660	800
	0.99	910	1050
A08	0.90	630	660
	0.95	760	790
	0.99	1040	1070
A09	0.90	220	310
	0.95	290	380
	0.99	430	520
A10	0.90	388	446
	0.95	475	533
	0.99	665	723
A11	0.90	272	274
	0.95	336	338
	0.99	474	476
A12	0.90	77	98
	0.95	105	126
	0.99	154	175
A13	0.90	266	315
	0.95	336	385
	0.99	483	532
A14	0.90	800	950
	0.95	1020	1170
	0.99	1540	1690

Item	Desired Fillrate	s	S
B01	0.90	150	230
	0.95	200	280
	0.99	310	390
B02	0.90	40	65
	0.95	55	80
	0.99	95	120
B03	0.90	170	250
	0.95	240	320
	0.99	380	460
B04	0.90	21	24
	0.95	29	32
	0.99	49	52
B05	0.90	180	250
	0.95	240	310
	0.99	380	450
B06	0.90	80	140
	0.95	100	160
	0.99	160	220
B07	0.90	60	120
	0.95	90	150
	0.99	150	210
B08	0.90	308	310
	0.95	376	378
	0.99	526	528
B09	0.90	80	160
	0.95	120	200
	0.99	200	280
B10	0.90	260	360
	0.95	380	480
	0.99	620	720
B12	0.90	85	90
	0.95	115	120
	0.99	190	195

Simulation Results - Two-Stage Heuristic at 90% Attachment 14

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	1158.137	6340.80	96	0.861	0
A02	7.075	250.098	1769.44	51	0.759	0
A03	31.205	115.147	3593.17	30	0.990	1
A04	33.906	114.902	3895.87	19	0.958	1
A05	6.049	111.569	674.88	38	0.793	0
A06	6.703	82.059	550.04	41	0.809	0
A07	9.161	279.412	2559.69	63	0.897	0
A08	17.468	349.824	6110.72	83	0.965	1
A09	10.987	193.628	2127.39	32	1.000	1
A10	17.164	261.490	4488.22	64	0.946	1
A11	57.509	214.824	12354.28	79	1.000	1
A12	35.970	54.284	1952.61	44	0.953	1
A13	20.977	135.882	2850.41	65	0.851	0
A14	5.292	542.255	2869.61	42	0.962	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			52137.12	747	0.910	0.571
B01	9.744	146.275	1425.30	21	0.963	1
B02	22.467	50.245	1128.86	8	1.000	1
B03	7.689	183.471	1410.71	17	1.000	1
B04	63.440	21.324	1352.76	20	1.000	1
B05	10.928	150.000	1639.20	31	0.922	1
B06	11.360	55.392	629.25	32	0.711	0
B07	6.916	79.118	547.18	11	0.940	1
B08	70.470	197.843	13942.00	80	0.983	1
B09	3.106	117.255	364.19	5	1.000	1
B10	3.576	308.039	1101.55	14	0.973	1
B12	28.399	78.431	2227.37	11	0.942	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			25768.38	250	0.949	0.909
			Total	Total	Average	Total % Meeting 90%
			77905.49	997	0.927	0.720

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	1724.900	9443.83	96	0.945	1
A02	7.075	345.784	2446.42	51	0.860	0
A03	31.205	154.951	4835.25	30	1.000	1
A04	33.906	148.775	5044.37	19	1.000	1
A05	6.049	153.333	927.51	38	0.871	0
A06	6.703	115.392	773.47	41	0.876	0
A07	9.161	387.941	3553.93	63	0.941	1
A08	17.468	476.490	8323.33	83	0.978	1
A09	10.987	263.627	2896.47	32	1.000	1
A10	17.164	345.931	5937.56	64	0.974	1
A11	57.509	278.824	16034.89	79	1.000	1
A12	35.970	81.186	2920.27	44	0.993	1
A13	20.977	197.578	4144.59	65	0.917	1
A14	5.292	756.275	4002.21	42	0.986	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			71284.09	747	0.953	0.786
B01	9.744	195.294	1902.94	21	0.996	1
B02	22.467	65.245	1465.86	8	1.000	1
B03	7.689	253.471	1948.94	17	1.000	1
B04	63.440	29.324	1860.28	20	1.000	1
B05	10.928	208.039	2273.45	31	0.967	1
B06	11.360	69.706	791.86	32	0.782	0
B07	6.916	108.529	750.59	11	0.970	1
B08	70.470	264.980	18673.14	80	0.998	1
B09	3.106	157.255	488.43	5	1.000	1
B10	3.576	427.451	1528.56	14	1.000	1
B12	28.399	107.745	3059.85	11	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			34743.91	250	0.974	0.909
			Total	Total	Average	Total % Meeting 90%
			106028.00	997	0.962	0.840

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	3138.040	17180.77	96	0.999	1
A02	7.075	596.863	4222.81	51	0.969	1
A03	31.205	244.951	7643.70	30	1.000	1
A04	33.906	228.775	7756.85	19	1.000	1
A05	6.049	263.137	1591.72	38	0.968	1
A06	6.703	197.549	1324.17	41	0.960	1
A07	9.161	626.275	5737.31	63	0.991	1
A08	17.468	752.471	13144.16	83	0.997	1
A09	10.987	403.627	4434.65	32	1.000	1
A10	17.164	533.637	9159.35	64	1.000	1
A11	57.509	416.824	23971.13	79	1.000	1
A12	35.970	130.049	4677.86	44	1.000	1
A13	20.977	337.304	7075.63	65	0.967	1
A14	5.292	1273.430	6738.99	42	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			114659.08	747	0.989	1.000
B01	9.744	305.196	2973.83	21	1.000	1
B02	22.467	105.245	2364.54	8	1.000	1
B03	7.689	393.471	3025.40	17	1.000	1
B04	63.440	49.324	3129.08	20	1.000	1
B05	10.928	346.667	3788.38	31	1.000	1
B06	11.360	120.490	1368.77	32	0.914	1
B07	6.916	167.941	1161.48	11	1.000	1
B08	70.470	414.863	29235.40	80	1.000	1
B09	3.106	237.255	736.91	5	1.000	1
B10	3.576	667.451	2386.80	14	1.000	1
B12	28.399	182.745	5189.78	11	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			55360.36	250	0.992	1.000
			Total	Total	Average	Total % Meeting 90%
			170019.44	997	0.991	1.000

Proofs of Lemmas and Theorems
(as they apply to the specific problem in this project)

- **Lemma 1:** $\beta(s,S) \leq \beta(s+1,S)$

Proof: By contradiction. Assume the opposite, that $\beta(s,S) > \beta(s+1,S)$. It follows that

$$1-\beta(s,S) < 1-\beta(s+1,S),$$

$$\frac{H(s,S)}{M(S-s)\mu} < \frac{H(s+1,S)}{M(S-s-1)\mu},$$

$$\frac{H(s,S)}{M(S-s-1)+m(S-s-1)} < \frac{H(s+1,S)}{M(S-s-1)},$$

$$M(S-s-1) * H(s,S) < [M(S-s-1)+m(S-s-1)] * H(s+1,S),$$

$$M(S-s-1)\sum_{j=0}^{S-s-1} m(j)[L(S-j \mid 2) - L(S-j \mid 1)] < [M(S-s-1)+m(S-s-1)]\sum_{j=0}^{S-s-2} m(j)[L(S-j \mid 2) - L(S-j \mid 1)],$$

$$M(S-s-1)[L(s+1 \mid 2) - L(s+1 \mid 1)] < \sum_{j=0}^{S-s-2} m(j)[L(S-j \mid 2) - L(S-j \mid 1)],$$

$$\sum_{j=0}^{S-s-2} m(j)[L(s+1 \mid 2) - L(s+1 \mid 1)] < \sum_{j=0}^{S-s-2} m(j)[L(S-j \mid 2) - L(S-j \mid 1)],$$

→which contradicts the fact that
$[L(s+1 \mid 2) - L(s+1 \mid 1)] > [L(S-j \mid 2) - L(S-j \mid 1)]$ for $j = 0 \ldots S-s-2$.
Hence what we assumed is false and $\beta(s,S) \leq \beta(s+1,S)$.

- **Lemma 2:** $\beta(s,S) \leq \beta(s+1,S+1)$

Proof: By contradiction. Assume the opposite, that $\beta(s,S) > \beta(s+1,S+1)$. It follows that

$$1-\beta(s,S) < 1-\beta(s+1,S+1),$$

$$\frac{H(s,S)}{M(S-s)\mu} < \frac{H(s+1,S+1)}{M(S+1-s-1)\mu},$$

$$H(s,S) < H(s+1,S+1),$$

$$\sum_{j=0}^{S-s-1} m(j)[L(S-j \mid 2) - L(S-j \mid 1)] < \sum_{j=0}^{S-s-1} m(j)[L(S+1-j \mid 2) - L(S+1-j \mid 1)],$$

→which contradicts the fact that. . .
$[L(S-j \mid 2) - L(S-j \mid 1)] > [L(S+1-j \mid 2) - L(S+1-j \mid 1)]$ for $j = 0 \ldots S-s-1$.
Hence what we assumed is false and $\beta(s,S) \leq \beta(s+1,S+1)$.

- **Lemma 3:** $c(s,S) \leq c(s+1,S)$

Already proven as Lemma 0 in [14].

- **Lemma 4:** $c(s,S) \leq c(s+1,S+1)$

Proof: By contradiction. Assume the opposite, that $c(s,S) > c(s+1,S+1)$. It follows that

$$\frac{K+h\sum_{j=0}^{S-s-1} m(j)[S-j-2\mu+L(S-j|2)]}{M(S-s)} > \frac{K+h\sum_{j=0}^{S-s-1} m(j)[S+1-j-2\mu+L(S+1-j|2)]}{M(S-s)},$$

$$\textstyle\sum_{j=0}^{S-s-1} m(j)[S-j-2\mu+L(S-j \mid 2)] > \sum_{j=0}^{S-s-1} m(j)[S+1-j-2\mu+L(S+1-j \mid 2)],$$

$$\textstyle\sum_{j=0}^{S-s-1} m(j)[-j+L(S-j \mid 2)] > \sum_{j=0}^{S-s-1} m(j)[1-j+L(S+1-j \mid 2)],$$

$$\textstyle\sum_{j=0}^{S-s-1} m(j)[-j+L(S-j \mid 2)] > \sum_{j=0}^{S-s-1} m(j)[1-j+L(S-j \mid 2)-F(S-j \mid 2)],$$

$$\text{where } F(S-j \mid 2) = 1-\textstyle\sum_{j=0}^{S-j} p(j) < 1.$$

$\rightarrow$The final statement then contradicts the fact that. . .
$[-j+L(S-j \mid 2)] < [1-j+L(S-j \mid 2)-F(S-j \mid 2)]$ for $j = 0 \ldots S-s-1$.
Hence what we assumed is false and $c(s,S) \leq c(s+1,S+1)$.

- **Theorem 1:** If (s^*, s^*+1) is the minimum feasible policy such that $\beta(s^*, s^*+1) \geq \bar{\beta}$, then all policies with $S < s^*$ are infeasible.

- **Theorem 2:** For every $\hat{S} \geq s^*+1$ there is one $\hat{s}$ for which (a) all policies with $s < \hat{s}$ and $S \leq \hat{S}$ are infeasible and (b) all policies with $s > \hat{s}$ and $S \geq \hat{S}$ are dominated.

Proofs: The proofs are by simple manipulation of the lemmas above.

Item	Desired Fillrate	s	S
A01	0.90	2740	3070
	0.95	3410	3730
	0.99	5000	5160
A02	0.90	450	540
	0.95	560	670
	0.99	860	930
A03	0.90	140	155
	0.95	180	195
	0.99	275	285
A04	0.90	125	145
	0.95	160	180
	0.99	240	260
A05	0.90	190	240
	0.95	250	290
	0.99	360	420
A06	0.90	140	230
	0.95	180	270
	0.99	280	340
A07	0.90	600	650
	0.95	700	770
	0.99	940	1020
A08	0.90	590	660
	0.95	720	790
	0.99	1050	1060
A09	0.90	220	310
	0.95	300	360
	0.99	430	510
A10	0.90	413	438
	0.95	507	524
	0.99	696	714
A11	0.90	266	274
	0.95	314	340
	0.99	468	476
A12	0.90	77	98
	0.95	105	119
	0.99	154	175
A13	0.90	266	315
	0.95	343	378
	0.99	490	525
A14	0.90	780	950
	0.95	1020	1170
	0.99	1540	1680

Item	Desired Fillrate	s	S
B01	0.90	160	210
	0.95	210	260
	0.99	330	370
B02	0.90	45	60
	0.95	55	80
	0.99	100	110
B03	0.90	180	240
	0.95	250	300
	0.99	390	440
B04	0.90	19	25
	0.95	27	33
	0.99	48	52
B05	0.90	180	250
	0.95	250	300
	0.99	380	440
B06	0.90	90	120
	0.95	120	140
	0.99	180	200
B07	0.90	70	110
	0.95	100	130
	0.99	160	200
B08	0.90	300	310
	0.95	366	378
	0.99	514	528
B09	0.90	40	160
	0.95	80	200
	0.99	160	280
B10	0.90	260	360
	0.95	380	460
	0.99	620	720
B12	0.90	65	95
	0.95	105	120
	0.99	180	195

Simulation Results - Almost-Exact Algorithm at 90% Attachment 17

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	1177.255	6445.47	78	0.866	0
A02	7.075	235.196	1664.01	53	0.743	0
A03	31.205	114.559	3574.81	40	0.997	1
A04	33.906	110.294	3739.63	21	0.972	1
A05	6.049	94.118	569.32	59	0.789	0
A06	6.703	69.314	464.61	49	0.803	0
A07	9.161	274.608	2515.68	90	0.895	0
A08	17.468	344.431	6016.52	73	0.963	1
A09	10.987	193.628	2127.39	32	1.000	1
A10	17.164	262.480	4505.21	84	0.943	1
A11	57.509	214.118	12313.71	70	1.000	1
A12	35.970	54.284	1952.60	44	0.953	1
A13	20.977	135.882	2850.40	65	0.851	0
A14	5.292	539.020	2852.49	41	0.961	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			51591.86	799	0.910	0.571
B01	9.744	138.922	1353.66	27	0.978	1
B02	22.467	49.755	1117.85	12	1.000	1
B03	7.689	181.255	1393.67	21	1.000	1
B04	63.440	20.265	1285.61	11	1.000	1
B05	10.928	150.000	1639.20	31	0.922	1
B06	11.360	46.078	523.45	43	0.672	0
B07	6.916	75.098	519.38	13	0.930	1
B08	70.470	197.549	13921.28	75	0.982	1
B09	3.106	115.294	358.10	4	0.944	1
B10	3.576	308.039	1101.55	14	0.973	1
B12	28.399	82.255	2335.96	9	0.967	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			25549.70	260	0.943	0.909
			Total	Total	Average	Total % Meeting 90%
			77141.55	1059	0.924	0.720

Simulation Results - Almost-Exact Algorithm at 95%

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	1747.549	9567.83	78	0.946	1
A02	7.075	338.628	2395.79	51	0.852	0
A03	31.205	154.510	4821.48	40	1.000	1
A04	33.906	144.510	4899.76	21	1.000	1
A05	6.049	136.078	823.14	61	0.874	0
A06	6.703	101.078	677.53	49	0.881	0
A07	9.161	378.726	3469.51	83	0.941	1
A08	17.468	470.804	8224.00	73	0.978	1
A09	10.987	251.961	2768.30	40	1.000	1
A10	17.164	347.314	5961.30	90	0.971	1
A11	57.509	275.235	15828.49	49	1.000	1
A12	35.970	75.696	2722.79	49	0.987	1
A13	20.977	195.177	4094.23	72	0.913	1
A14	5.292	756.275	4002.21	42	0.986	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			70256.34	798	0.952	0.786
B01	9.744	188.333	1835.12	27	1.000	1
B02	22.467	65.245	1465.86	8	1.000	1
B03	7.689	245.177	1885.17	23	1.000	1
B04	63.440	28.265	1793.13	11	1.000	1
B05	10.928	204.314	2232.74	36	0.952	1
B06	11.360	61.078	693.85	46	0.760	0
B07	6.916	100.098	692.28	16	0.980	1
B08	70.470	264.451	18635.86	73	0.997	1
B09	3.106	154.510	479.91	4	1.000	1
B10	3.576	407.451	1457.04	14	1.000	1
B12	28.399	107.451	3051.50	10	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			34222.46	268	0.972	0.909
			Total	Total	Average	Total % Meeting 90%
			104478.80	1066	0.961	0.840

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	3139.412	17188.28	85	0.997	1
A02	7.075	575.098	4068.82	58	0.971	1
A03	31.205	244.951	7643.70	42	1.000	1
A04	33.906	224.510	7612.24	21	1.000	1
A05	6.049	251.471	1521.15	55	0.973	1
A06	6.703	174.118	1167.11	60	0.955	1
A07	9.161	616.078	5643.89	81	0.995	1
A08	17.468	745.412	13020.86	95	0.996	1
A09	10.987	396.177	4352.80	35	1.000	1
A10	17.164	534.755	9178.53	90	1.000	1
A11	57.509	416.118	23930.53	70	1.000	1
A12	35.970	130.049	4677.86	44	1.000	1
A13	20.977	334.696	7020.92	72	0.965	1
A14	5.292	1267.843	6709.43	43	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			113736.11	851	0.989	1.000
B01	9.744	305.098	2972.87	34	1.000	1
B02	22.467	101.520	2280.85	14	1.000	1
B03	7.689	385.177	2961.63	23	1.000	1
B04	63.440	48.069	3049.50	13	1.000	1
B05	10.928	339.118	3705.88	31	1.000	1
B06	11.360	110.980	1260.73	46	0.910	1
B07	6.916	164.020	1134.36	13	1.000	1
B08	70.470	414.157	29185.64	72	1.000	1
B09	3.106	234.510	728.39	4	1.000	1
B10	3.576	667.451	2386.80	14	1.000	1
B12	28.399	182.451	5181.43	10	1.000	1
			Subtotal	Subtotal	Subaverage	% Meeting 90%
			54848.09	274	0.992	1.000
			Total	Total	Average	Total % Meeting 90%
			168584.19	1125	0.990	1.000

A01

Interval	Prob	O	E	Stat
0 thr 13	0.1620	16	16.5274	0.0168
14 thr 30	0.1656	9	16.8946	3.6890
31 thr 52	0.1680	13	17.1365	0.9985
53 thr 82	0.1643	16	16.7598	0.0344
83 thr 133	0.1666	17	16.9884	0.0000
134 thr inf	0.1735	31	17.6933	10.0076
				14.7464

A02

Interval	Prob	O	E	Stat
0 thr 1	0.1884	28	19.2204	4.0104
2 thr 3	0.1300	3	13.2644	7.9429
4 thr 7	0.1878	17	19.1603	0.2436
8 thr 12	0.1567	8	15.9797	3.9848
13 thr 21	0.1630	15	16.6283	0.1594
22 thr inf	0.1740	31	17.7470	9.8970
				26.2381

A03

Interval	Prob	O	E	Stat
0	0.2504	41	25.5359	9.3647
1	0.1245	9	12.6982	1.0771
2 thr 3	0.1576	19	16.0720	0.5334
4 thr 6	0.1442	14	14.7076	0.0340
7 thr 12	0.1542	9	15.7279	2.8780
13 thr inf	0.1692	10	17.2583	3.0526
				16.9399

A04

Interval	Prob	O	E	Stat
0	0.2170	58	22.1317	58.1306
1	0.1322	12	13.4872	0.1640
2 thr 3	0.1788	14	18.2326	0.9826
4 thr 6	0.1662	5	16.9491	8.4241
7 thr 11	0.1496	4	15.2583	8.3069
12 thr inf	0.1563	9	15.9410	3.0222
				79.0305

A05

Interval	Prob	O	E	Stat
0	0.2293	18	23.3911	1.2425
1	0.1446	6	14.7540	5.1940
2	0.1084	9	11.0585	0.3832
3 thr 4	0.1548	13	15.7853	0.4915
5 thr 9	0.2038	22	20.7895	0.0705
10 thr inf	0.1590	34	16.2217	19.4844
				26.8661

A06

Interval	Prob	O	E	Stat
0 thr 1	0.2307	20	23.5353	0.5311
2	0.1179	4	12.0308	5.3607
3 thr 4	0.1993	7	20.3296	8.7399
5 thr 6	0.1465	19	14.9409	1.1027
7 thr 9	0.1406	19	14.3441	1.5113
10 thr inf	0.1649	33	16.8193	15.5664
				32.8120

A07

Interval	Prob	O	E	Stat
0 thr 6	0.1645	15	16.7808	0.1890
7 thr 11	0.1729	17	17.6337	0.0228
12 thr 16	0.1607	20	16.3890	0.7956
17 thr 23	0.1780	23	18.1600	1.2900
24 thr 32	0.1493	12	15.2253	0.6833
33 thr inf	0.1746	15	17.8112	0.4437
				3.4243

A08

Interval	Prob	O	E	Stat
0 thr 3	0.1520	20	15.5041	1.3037
4 thr 8	0.1980	13	20.1971	2.5646
9 thr 13	0.1640	18	16.7261	0.0970
14 thr 19	0.1490	18	15.2021	0.5150
20 thr 30	0.1695	22	17.2869	1.2850
31 thr inf	0.1675	11	17.0838	2.1665
				7.9318

A09

Interval	Prob	O	E	Stat
0	0.1130	13	11.5224	0.1895
1 thr 2	0.1998	27	20.3770	2.1527
3 thr 5	0.2245	32	22.8992	3.6169
6 thr 8	0.1532	16	15.6270	0.0089
9 thr 13	0.1523	9	15.5353	2.7492
14 thr inf	0.1572	5	16.0392	7.5978
				16.3150

A10

Interval	Prob	O	E	Stat
0 thr 30	0.1623	26	16.5500	5.3959
31 thr 59	0.1642	23	16.7500	2.3321
60 thr 95	0.1726	19	17.6036	0.1108
96 thr 138	0.1561	13	15.9229	0.5365
139 thr 215	0.1733	12	17.6790	1.8242
216 thr inf	0.1715	9	17.4945	4.1245
				14.3241

A11

Interval	Prob	O	E	Stat
0 thr 5	0.1720	40	17.5399	28.7604
6 thr 12	0.1503	18	15.3317	0.4644
13 thr 23	0.1775	23	18.1098	1.3205
24 thr 38	0.1665	8	16.9828	4.7514
39 thr 63	0.1618	13	16.5035	0.7437
64 thr inf	0.1719	0	17.5323	17.5323
				53.5726

A12

Interval	Prob	O	E	Stat
0	0.3710	30	37.8426	1.6253
1	0.1760	18	17.9502	0.0001
2	0.1139	12	11.6150	0.0128
3 thr 4	0.1391	12	14.1872	0.3372
5 thr 7	0.1038	21	10.5874	10.2408
8 thr inf	0.0963	9	9.8177	0.0681
				12.2843

A13

Interval	Prob	O	E	Stat
0 thr 1	0.1440	15	14.6893	0.0066
2 thr 4	0.1901	15	19.3927	0.9950
5 thr 8	0.1946	16	19.8481	0.7461
9 thr 12	0.1396	9	14.2435	1.9303
13 thr 20	0.1689	26	17.2230	4.4729
21 thr inf	0.1628	21	16.6034	1.1642
				9.3150

A14

Interval	Prob	O	E	Stat
0	0.1166	43	11.8928	81.3656
1 thr 4	0.2172	7	22.1505	10.3627
5 thr 10	0.1829	7	18.6559	7.2824
11 thr 17	0.1358	6	13.8537	4.4522
18 thr 34	0.1795	10	18.3070	3.7694
35 thr inf	0.1680	29	17.1402	8.2061
				115.4383

B01

Interval	Prob	O	E	Stat
0	0.2634	35	26.8650	2.4634
1	0.1564	21	15.9487	1.5999
2	0.1131	13	11.5356	0.1859
3 thr 4	0.1550	12	15.8105	0.9184
5 thr 8	0.1649	14	16.8159	0.4715
9 thr inf	0.1473	7	15.0243	4.2857
				9.9247

B02

Interval	Prob	O	E	Stat
0	0.4584	75	46.7530	17.0661
1	0.1780	13	18.1561	1.4643
2	0.1057	6	10.7805	2.1199
3	0.0700	5	7.1393	0.6410
4 thr 5	0.0837	2	8.5377	5.0062
6 thr inf	0.1042	1	10.6334	8.7274
				35.0248

B03

Interval	Prob	O	E	Stat
0	0.3508	49	35.7826	4.8823
1	0.1493	18	15.2304	0.5036
2	0.0980	8	9.9991	0.3997
3 thr 4	0.1274	9	12.9958	1.2286
5 thr 8	0.1336	13	13.6322	0.0293
9 thr inf	0.1408	5	14.3600	6.1009
				13.1444

B04

Interval	Prob	O	E	Stat
0	0.7573	79	77.2441	0.0399
1	0.0739	3	7.5401	2.7337
2	0.0379	0	3.8706	3.8706
3 thr 4	0.0426	12	4.3431	13.4990
5 thr 9	0.0463	3	4.7219	0.6279
10 thr inf	0.0420	5	4.2801	0.1211
				20.8923

B05

Interval	Prob	O	E	Stat
0	0.2888	36	29.4604	1.4516
1	0.1493	8	15.2254	3.4289
2	0.1042	9	10.6263	0.2489
3 thr 4	0.1413	12	14.4117	0.4036
5 thr 8	0.1538	20	15.6858	1.1865
9 thr inf	0.1627	17	16.5904	0.0101
				6.7296

B06

Interval	Prob	O	E	Stat
0	0.3544	39	36.1501	0.2247
1	0.1929	12	19.6786	2.9962
2	0.1267	7	12.9226	2.7144
3	0.0879	3	8.9699	3.9733
4 thr 5	0.1081	12	11.0240	0.0864
6 thr inf	0.1299	29	13.2549	18.7033
				28.6982

B07

Interval	Prob	O	E	Stat
0	0.5737	65	58.5201	0.7175
1	0.1626	14	16.5852	0.4030
2	0.0869	14	8.8655	2.9737
3	0.0537	2	5.4811	2.2109
4 thr 5	0.0598	3	6.0973	1.5733
6 thr inf	0.0632	4	6.4509	0.9312
				8.8096

B08

Interval	Prob	O	E	Stat
0 thr 5	0.1633	27	16.6564	6.4234
6 thr 14	0.1701	15	17.3477	0.3177
15 thr 26	0.1654	20	16.8758	0.5784
27 thr 44	0.1693	14	17.2722	0.6199
45 thr 74	0.1617	18	16.4962	0.1371
75 thr inf	0.1701	8	17.3517	5.0401
				13.1166

B09

Interval	Prob	O	E	Stat
0	0.8623	91	87.9525	0.1056
1	0.0952	6	9.7088	1.4168
2	0.0273	4	2.7810	0.5343
3	0.0094	0	0.9598	0.9598
4	0.0035	1	0.3594	1.1417
5 thr inf	0.0023	0	0.2384	0.2384
				4.3965

B10

Interval	Prob	O	E	Stat
0	0.6229	82	63.5351	5.3664
1	0.1189	0	12.1267	12.1267
2	0.0643	6	6.5537	0.0468
3 thr 4	0.0724	4	7.3850	1.5516
5 thr 7	0.0540	5	5.5089	0.0470
8 thr inf	0.0676	5	6.8906	0.5187
				19.6572

B12

Interval	Prob	O	E	Stat
0	0.8005	89	81.6532	0.6610
1	0.0680	2	6.9387	3.5152
2	0.0337	0	3.4414	3.4414
3 thr 4	0.0363	2	3.7062	0.7854
5 thr 8	0.0319	3	3.2525	0.0196
9 thr inf	0.0295	6	3.0080	2.9760
				11.3987

Simulation Results - Almost-Exact/Croston Hybrid

	c	Avg OH Inv	$ OH Inv	# Orders	Fillrate	Meet 90%?
A01	5.475	1177.255	6445.47	78	0.866	0
A02	7.075	549.314	3886.40	54	0.957	1
A03	31.205	73.480	2292.94	43	0.930	1
A04	33.906	102.206	3465.40	23	0.975	1
A05	6.049	257.843	1559.69	62	0.994	1
A06	6.703	69.314	464.61	49	0.803	0
A07	9.161	274.608	2515.68	90	0.895	0
A08	17.468	344.431	6016.52	73	0.963	1
A09	10.987	193.628	2127.39	32	1.000	1
A10	17.164	262.480	4505.21	84	0.943	1
A11	57.509	104.529	6011.36	54	0.974	1
A12	35.970	54.284	1952.60	44	0.953	1
A13	20.977	135.882	2850.40	65	0.851	0
A14	5.292	762.255	4033.85	46	0.984	1
			Subtotal 48127.52	Subtotal 797	Subaverage 0.935	% Meeting 90% 0.714
B01	9.744	138.922	1353.66	27	0.978	1
B02	22.467	20.539	461.45	20	0.963	1
B03	7.689	181.255	1393.67	21	1.000	1
B04	63.440	5.216	330.90	21	0.705	0
B05	10.928	119.706	1308.15	52	0.893	0
B06	11.360	82.157	933.30	49	0.833	0
B07	6.916	75.098	519.38	13	0.930	1
B08	70.470	148.235	10446.12	67	0.941	1
B09	3.106	115.294	358.10	4	0.944	1
B10	3.576	108.628	388.45	20	0.761	0
B12	28.399	82.255	2335.96	9	0.967	1
			Subtotal 19829.14	Subtotal 303	Subaverage 0.901	% Meeting 90% 0.636
			Total 67956.66	Total 1100	Average 0.920	Total % Meeting 90% 0.680

Designing an (s, S) Inventory Control System

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18 July 1997

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References

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